02-9005-07-SI
REV. NO. 0

FINAL DRAFT
SITE INSPECTION REPORT
MONSANTO COMPANY
HAMILTON TWP., NEW JERSEY
VOLUME 1 OF 2

PREPARED UNDER

TECHNICAL DIRECTIVE DOCUMENT NO. 02-9005-07
CONTRACT NO. 68-01-7346

FOR THE

ENVIRONMENTAL SERVICES DIVISION
U.S. ENVIRONMENTAL PROTECTION AGENCY

JUNE 28, 1991

HALLIBURTON NUS ENVIRONMENTAL CORPORATION
SUPERFUND DIVISION

SUBMITTED BY:

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247751

SITE SUMMARY AND RECOMMENDATIONS

Monsanto Company is located at 584 Rt. 130, in Hamilton Twp., Mercer County, New Jersey. The site property consists of approximately 17 acres bounded on the south by Rt. 130, on the west by Georgia Pacific, and on the north and east by wooded areas. Figures 1 and 2 provide a Site Location Map and Site Map, respectively. The Sun Chemical Corporation currently owns the Monsanto Company property. The Hilman Group previously owned the site property, during which Polychrome Corporation operated an automatic plate processing equipment assembly and maintained a national distribution warehouse for graphics arts products (Ref. Nos. 10, 15, 17).

The site is located approximately 5 miles east of the Delaware River. The nearest surface water is Back Creek which flows outside of the northeastern end of the property, approximately 400 feet away. The stream flows west into the Crosswicks Creek system and eventually into the Delaware River. The site terrain is flat, and mostly paved around the main warehouse. A railroad track spur is located immediately west of the main warehouse. The track runs north locally, turning northeasterly as it joins with the Conrail Railroad track (Ref. Nos. 16, 17).

Monsanto Company, which was in operation from 1961 to 1982, was responsible for the manufacture of plastic bottles. Plastic pellets were received from outside manufacturers in railcars and occasionally by truck, and stored in silos on-site. From the silos, the pellets were transferred to feed hoppers, through grinders and into extruders. Electric heat and the mechanical energy and pressure of the extrusion process melted the pellets. The melted plastic was extruded into molds and blown with air to the shape of the mold.

The bottles were then trimmed of excess plastic, run through an open flame, packed in cartons, and palletized for shipment. The flame treatment was needed to make glue and/or ink stick to the surface. The flames were provided by individual natural gas units at each production line. Propane was used as a backup in cold weather.

The process equipment used hydraulic fluids in the extruders and mold heads. Various lubricants were also used in the turn tables, conveyors, fork lifts, and other equipment.

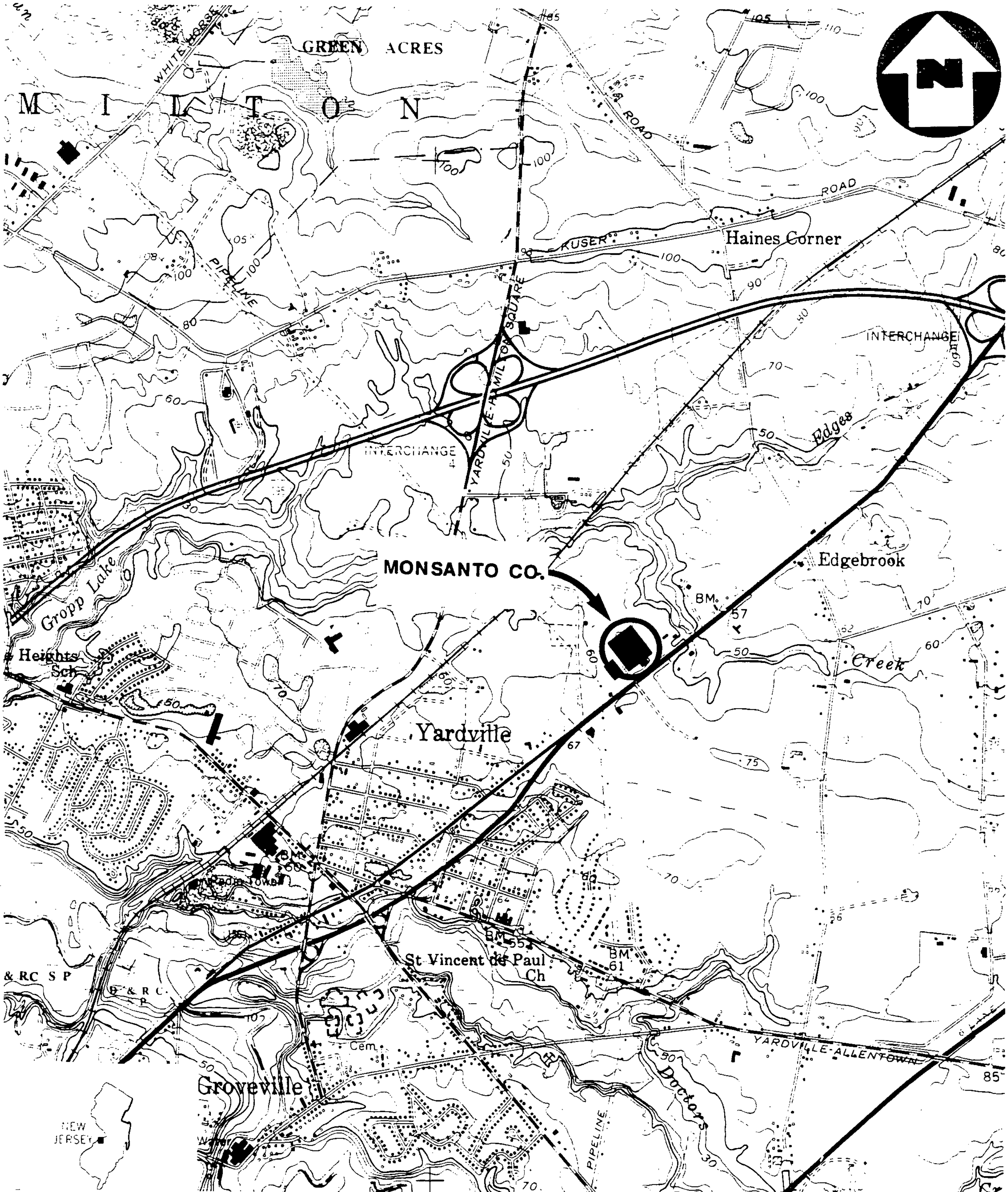
From 1961 until 1965, the plant disposed of used machine oil by putting it on the railroad tracks to control weeds. In 1965, the ballast under the tracks was removed to a depth of 18 inches and replaced with clean ballast. After 1965, used oil was collected in a tank outside the maintenance shop and sold to reclaimers. The tank was removed when Monsanto discontinued their operations in 1982. A small amount of oil continued to find its way to the tracks until 1973. In early 1973, all oil flow to the tracks was stopped and the oil stained ballast was replaced with new ballast.

SITE SUMMARY AND RECOMMENDATIONS (CONT'D)

Non-contact cooling water was pumped from a cooling tower through the extruders and discharged to a hot well through piping in the trench which runs across one end of the building, and returned to the cooling tower to be cycled through again.

The maintenance shop used solvents for cleaning machine parts. Small quantities of solvents were also used in the quality control lab for wiping the surfaces of the bottles to test adhesion properties and for other quality checks. Solvents were used as carriers for the inks during the short period when the silk-screening process was operated. The method of disposal for these solvents is unknown (Ref. Nos. 12, 19).

When Monsanto's activities were terminated, contaminated sorbent materials were placed temporarily in an area directly south of the loading dock. These materials were removed and the underlying soil was eventually remediated. During the on-site reconnaissance conducted by personnel from NUS Corporation Region 2 FIT on June 5, 1991, this area of remediation was noted to be approximately a 70 square foot patch of sand. Two propane tanks, a propane fill area, and a transformer are also on site (Ref. No. 17). Environ Corporation was contracted by Polychrome in 1986 to generate a sampling plan and perform a comprehensive sampling of the site. Analytical data from sampling completed in August 1988, March 1990, and November 1990 indicate volatile, semivolatile, polychlorinated biphenyl (PCB) and heavy metal contamination in the soil and volatile and semivolatile contamination in the on-site monitoring wells (Ref. No. 14). Based on the lack of groundwater use, and low waste quantity, a recommendation of **NO FURTHER REMEDIAL ACTION PLANNED** under CERCLA/SARA, is given for the Monsanto Company site.



(QUAD) TRENTON EAST, N.J.- PA.

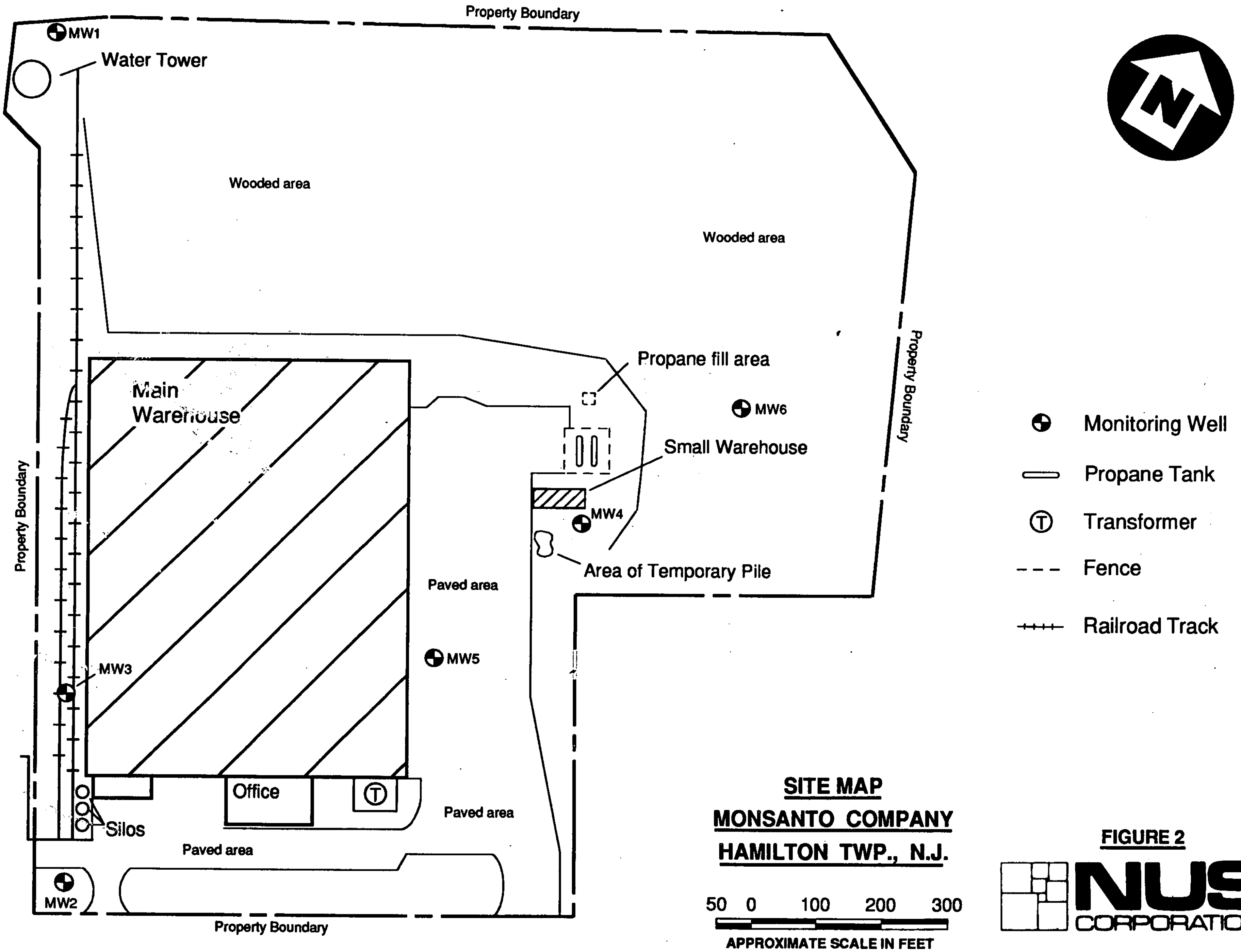
SITE LOCATION MAP

MONSANTO CO., HAMILTON TWP., N.J.

SCALE: 1"= 2000'

FIGURE 1

NUS CORPORATION



SITE MAP
MONSANTO COMPANY
HAMILTON TWP., N.J.

FIGURE 2

NUS CORPORATION

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SITE ASSESSMENT REPORT: SITE INSPECTION

PART I: SITE INFORMATION

1. Site Name/Alias Monsanto Company/Polychrome

   Street 584 Rte. 130

   City Hamilton Twp. State NJ Zip 08619

2. County Mercer County Code 021 Cong. Dist. 4

3. EPA ID No. NJD980210009

4. Block No. 598 Lot No. 41, 44

5. Latitude 40° 11′ 19″ N Longitude 74° 39′ 22″ W

   USGS Quad. Trenton East, NJ-PA

6. Owner Sun Chemical Corp. Tel. No. (201) 224- 4600

   Street 222 Bridge Plaza So.

   City Fort Lee State NJ Zip 07024

7. Operator Sun Chemical Corp. Tel. No. (201) 224-4600

   Street 222 Bridge Plaza So.

   City Fort Lee State NJ Zip 07024

8. Type of Ownership

   ☒ Private ☐ Federal ☐ State
   ☐ County ☐ Municipal ☐ Unknown ☐ Other ______

9. Owner/Operator Notification on File

   ☐ RCRA 3001 Date ______ ☐ CERCLA 103c Date ______
   ☒ None ☐ Unknown

10. Permit Information

Permit	Permit No.	Date Issued	Expiration Date	Comments
None Available				

11. Site Status

   ☐ Active ☒ Inactive ☐ Unknown

12. Years of Operation 1961 to 1982

13. Identify the types of waste sources (e.g., landfill, surface impoundment, piles, stained soil, above- or below-ground tanks or containers, land treatment, etc.) on site. Initiate as many waste unit numbers as needed to identify all waste sources on site.

(a) **Waste Sources**

Waste Unit No.	Waste Source Type	Facility Name for Unit
1	Contaminated Soil	Temporary pile
2	Contaminated Soil	Land Treatment

(b) **Other Areas of Concern**

Identify any miscellaneous spills, dumping, etc. on site; describe the materials and identify their locations on site.

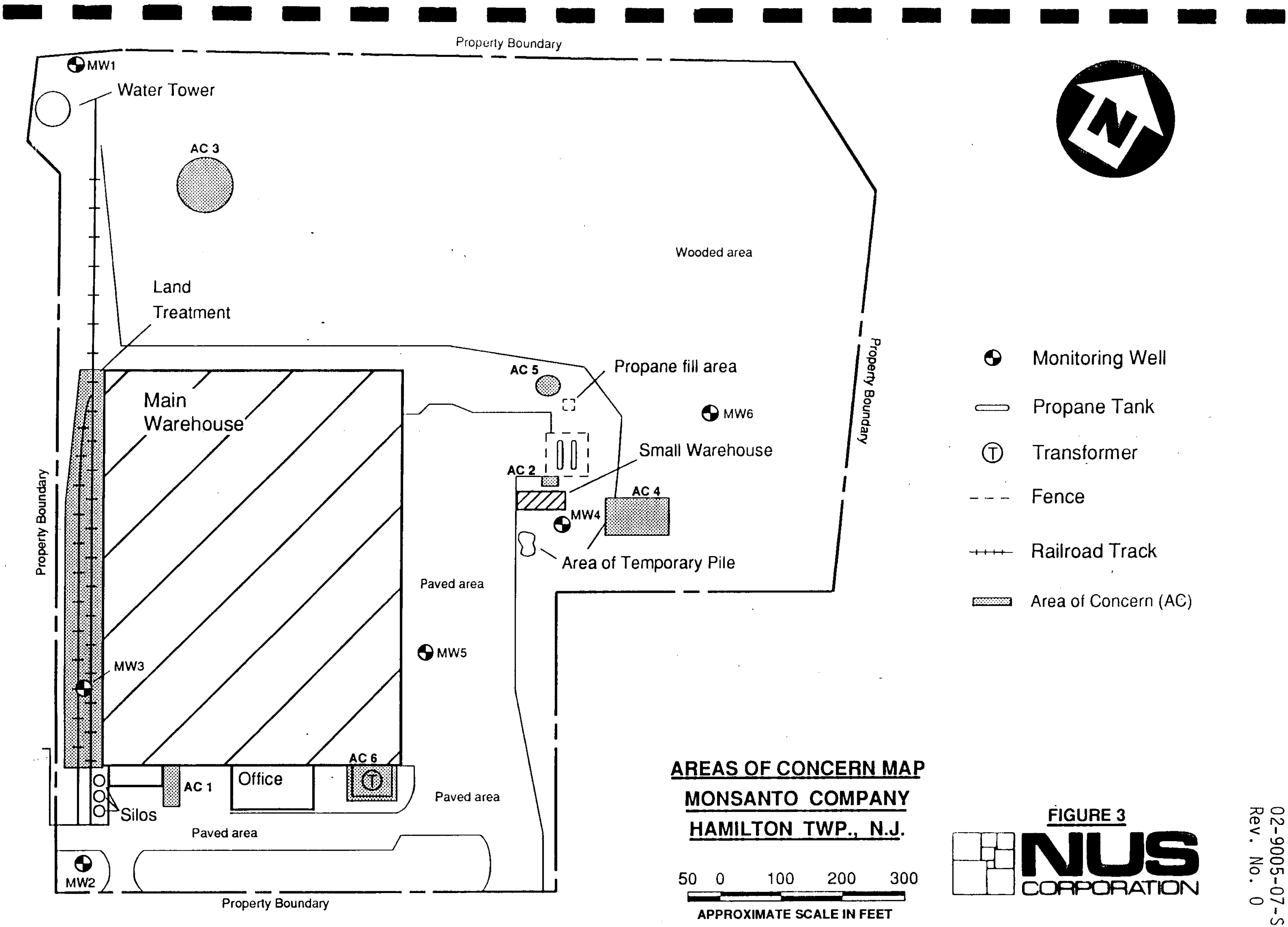
* Area of Concern	Description
1	Contaminated soil located in the area of former PCB storage dumpster.
2	Contamianted soil adjacent to former drum storage pad.
3	Contaminated soil in the area of distressed vegetation north of the main warehouse.
4	Contaminated soil in the area of distressed vegetation located at the eastern edge of parking lot.
5	Contaminated soil in the area of distressed vegetation adjacent to propane tanks.
6	Transformer substation.

* Refer to Figure 3

14. Information available from

Contact Amy Brochu   Agency U.S. EPA   Tel. No. (908) 906-6802

Preparer Anthony Bonasera   Agency NUS Corp. Region 2 FIT   Date June 30, 1991



AREAS OF CONCERN MAP
MONSANTO COMPANY
HAMILTON TWP., N.J.

FIGURE 3

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PART II: WASTE SOURCE INFORMATION

For each of the waste units identified in Part I, complete the following items

Waste Unit 1 - FormerTemporary Pile

Source Type

____	Landfill	X	Contaminated Soil
____	Surface Impoundment	____	Pile
____	Drums	____	Land Treatment
____	Tanks/Containers	____	Other

Description:

Contaminated soil was found directly south of the loading dock. It is documented that contaminated sorbent materials were placed there temporarily.

Hazardous Waste Quantity

The quantity of contaminated soil is an area approximately 70 square feet.

Hazardous Substances/Physical State

The hazardous substances are tetrachloroethylene, 1,1,1-trichloroethane, toluene, methylene chloride, Di-sec-octyl-Phthalate and Benzidine, in a liquid state.

Ref. Nos. 13, 14, 17

PART II: WASTE SOURCE INFORMATION

For each of the waste units identified in Part I, complete the following items

Waste Unit 2 - Land Treatment

Source Type

____	Landfill	X	Contaminated Soil
____	Surface Impoundment	____	Pile
____	Drums	____	Land Treatment
____	Tanks/Containers	____	Other

Description:

Contaminated soil was documented to have existed west of the main warehouse along a section of railroad track. Waste oil had been dumped on this area for approximately four years.

Hazardous Waste Quantity

The hazardous waste quantity is an area approximately 200 square feet.

Hazardous Substances/Physical State

The hazardous substance is waste oil in a liquid state.

Ref. Nos. 13, 14, 17

PART III: SAMPLING RESULTS
EXISTING ANALYTICAL DATA

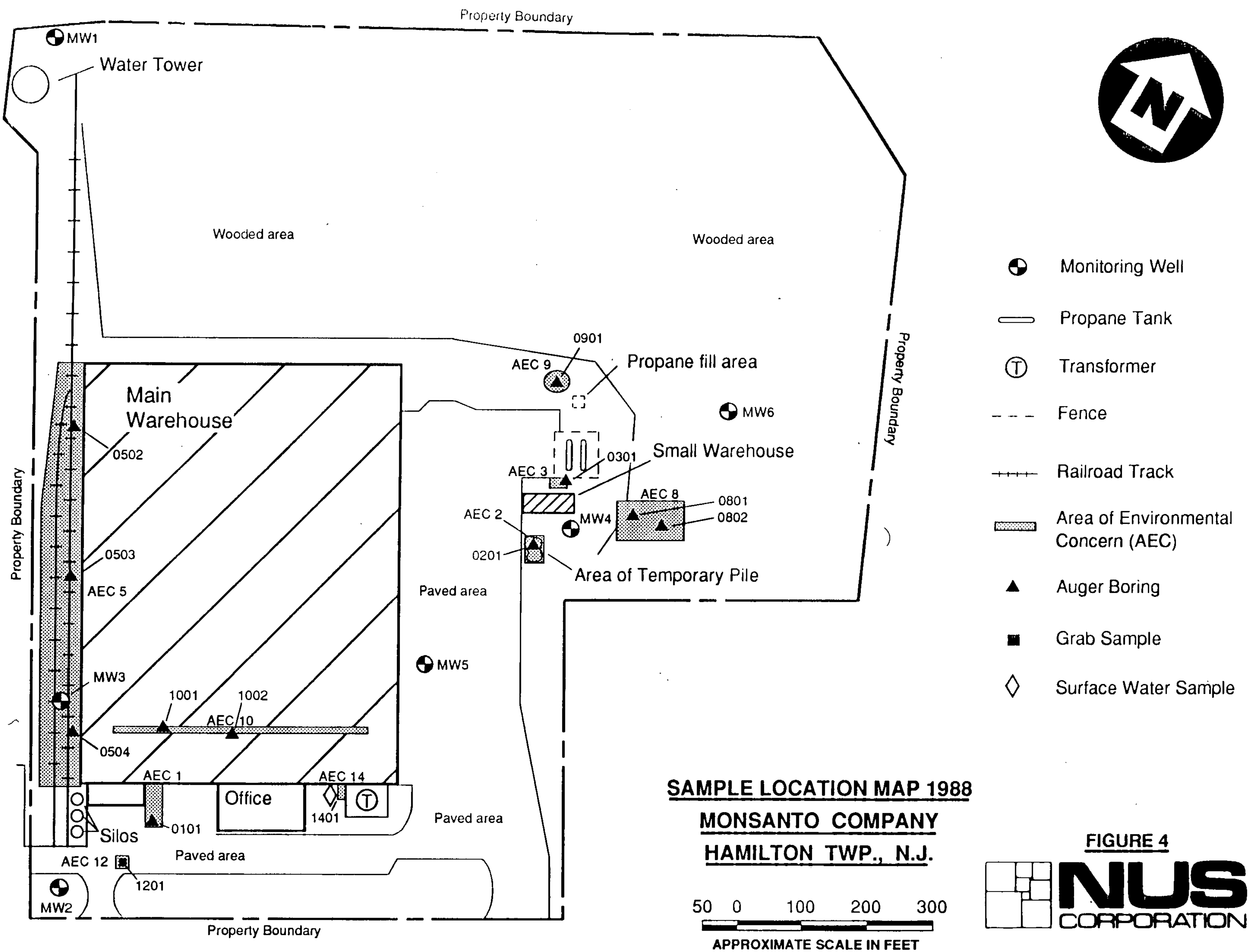
Environ Corporation first submitted a sampling plan for Polychrome Corporation on July 15, 1986, at the NJDEP's request. The property was inspected on February 3, 1987 and March 27, 1987, and a revised sampling plan was generated identifying 14 areas of environmental concern (AEC's). Figures 4 and 5 provide locations for the pertinent AEC's. The revised sampling plan was implemented on August 1 and 2, 1988 involving the collection of 30 soil samples from 12 borings and a storm sewer catch basin, and one water sample from a sump. Subsequently, Environ completed five hand auger borings in the wooded portion of the property. Table I provides the sampling results, and Figure 4 provides a sample location map.

In December 1989, and January 1990 three monitoring wells were installed. Additional sampling was completed in March and November 1990. Soil sampling results and a sample location map for March, 1990 are provided in Table 2 and Figure 5 respectively. Groundwater sampling results and a sample location map for November 1990 are provided in Table 3 and Figure 6 respectively.

Ref. Nos. 12, 13, 14

SITE INSPECTION RESULTS

A sampling site inspection was not conducted by NUS FIT 2 personnel. Environ Corporation provided data adequate to assess on-site contamination.



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SITE NAME: MONSANTO COMPANY
TDD#: 02-9005-07
SAMPLING DATE: 8/1/88
LAB NAME: AnalytiKEM

TEST REPORT NO. A16894

TABLE 1

VOLATILES Sample Designation Matrix Units	Method Blank 1 Nonaqueous ug/kg	Method Blank 1 Nonaqueous ug/kg	0201-SB01 Soil ug/kg	0201-SB02 Soil ug/kg	0201-SB03 Soil ug/kg	0301-SB01 Soil ug/kg	Method Blank Aqueous ug/l	880801-TB * Aqueous ug/l
Chloromethane								
Bromomethane								
Vinyl Chloride								
Chloroethane								
Methylene Chloride				800	140 J	51 J	5.4 J	1.8 J
1,1-Dichloroethene								
1,1-Dichloroethane								
trans-1,2-Dichloroethene								
Chloroform								
1,2-Dichloroethane								
1,1,1-Trichloroethane								
Carbon Tetrachloride								
Bromodichloromethane								
1,2-Dichloropropane								
trans-1,3-Dichloropropene								
Trichloroethene								
Dibromochloromethane								
1,1,2-Trichloroethane								
Benzene								
cis-1,3-Dichloropropene								
2-Chloroethyl Vinyl Ether								
Bromoform								
Tetrachloroethene								
1,1,2,2-Tetrachloroethane							0.3 J	
Toluene			420	3600	840	590		
Chlorobenzene								
Ethylbenzene								
m-Xylene								
o,p-Xylene								

NOTES:
Blank space - Compound analyzed for but not detected
J - Compound was detected at a level below the practical quantitation limit. The level reported is approximate
* - Denotes Field Blank

SITE NAME: MONSANTO COMPANY
TDD#: 02-9005-07
SAMPLING DATE: 8/1/88
LAB NAME: AnalytiKEM

TEST REPORT NO. A16894

TABLE 1 (CONT'D)

VOLATILES Sample Designation Matrix Units	Method Blank 2 Nonaqueous ug/kg	0301-SB03 Soil ug/kg	0802-SB01 Soil ug/kg	Method Blank 2 Nonaqueous ug/kg	0802-SB02 Soil ug/kg	Method Blank 3 Nonaqueous ug/kg	0301-SB02 Soil ug/kg	0801-SB01 Soil ug/kg
Chloromethane								
Bromomethane								
Vinyl Chloride								
Chloroethane								
Methylene Chloride					410			1800
1,1-Dichloroethene								
1,1-Dichloroethane								
trans-1,2-Dichloroethene								
Chloroform								
1,2-Dichloroethane								
1,1,1-Trichloroethane								
Carbon Tetrachloride								
Bromodichloromethane								
1,2-Dichloropropane								
trans-1,3-Dichloropropene								
Trichloroethene								
Dibromochloromethane								
1,1,2-Trichloroethane								
Benzene								
cis-1,3-Dichloropropene								
2-Chloroethyl Vinyl Ether								
Bromoform								
Tetrachloroethene								
1,1,2,2-Tetrachloroethane								
Toluene					1300			2800
Chlorobenzene								
Ethylbenzene								
m-Xylene								
o,p-Xylene								

NOTES:
Blank space - Compound analyzed for but not detected
J - Compound was detected at a level below the practical quantitation limit. The level reported is approximate

SITE NAME: MONSANTO COMPANY
TDD#: 02-9005-07
SAMPLING DATE: 8/1/88
LAB NAME: AnalytiKEM

TEST REPORT NO. A16894

TABLE 1 (CONT'D)

SEMI-VOLATILES Sample Designation Matrix Units	Method Blank Nonaqueous ug/kg	0201-SB01 Soil ug/kg	0201-SB02 Soil ug/kg	0201-SB03 Soil ug/kg
N-Nitrosodimethylamine				
Bis(2-chloroethyl) Ether				
1,3-Dichlorobenzene				
1,4-Dichlorobenzene				
1,2-Dichlorobenzene				
Bis(2-chloroisopropyl) Ether				
N-Nitrosodipropylamine				
Hexachloroethane				
Nitrobenzene				
Isophorene				
Bis(2-chloroethoxy)methane				
1,2,4-Trichlorobenzene				
Napthalene				
Hexachlorocyclopentadiene				
2-Chloronapthalene				
Dimethyl Phtalate				
Acenapthylene				
Acenapthene				

NOTES:
Blank space - Compound analyzed for but not detected
J - Compound was detected at a level below the practical quantitation limit. The level reported is approximate

SITE NAME: MONSANTO COMPANY
TDD#: 02-9005-07
SAMPLING DATE: 8/1/88
LAB NAME: AnalytiKEM

TEST REPORT NO. A16894

TABLE 1 (CONT'D)

SEMI-VOLATILES Sample Designation Matrix Units	Method Blank Nonaqueous ug/kg	0201-SB01 Soil ug/kg	0201-SB02 Soil ug/kg	0201-SB03 Soil ug/kg
2,4-Dinitrotoluene				
2,6-Dinitrotoluene				
Diethyl Phthalate		1100		
4-Chlorophenyl Phenyl Ether				
Flourene		90J		
N-Nitrosodiphenylamine			26J	
4-Bromophenyl Phenyl Ether				
Hexachlorobenzene				
Phenanthrene		800		33J
Anthracene		190J		
Dibutyl Phthalate	22J	170J		23J
Flouranthene		1500		62J
Benzidine				
Pyrene		1100		46J
Butylbenzyl Phthalate				
3,3'-Dichlorobenzidine				
Benzo(a)anthracene		780		
Bis(2-ethylhexyl) Phthalate	18J	120000	170J	1200
Chrysene				
Dioctyl Phthalate				
Benzo(b)flouranthene		500		
Benzo(k)flouranthene		420		
Benzo(a)pyrene		430		
Indeno(1,2,3-cd)pyrene		180J		
Dibenzo(a,h)anthracene				
Benzo(g,h,i)perylene				

NOTES:
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SITE NAME: MONSANTO COMPANY
TDD#: 02-9005-07
SAMPLING DATE: 8/1/88
LAB NAME: AnalytiKEM

TEST REPORT NO. A16894

TABLE 1 (CONT'D)

SEMI-VOLATILES Sample Designation Matrix Units	Method Blank Soil ug/kg	0301-SB01 Soil ug/kg	0301-SB02 Soil ug/kg	0301-SB03 Soil ug/kg	Method Blank Nonaqueous ug/kg	0801-SB01 Soil ug/kg	0802-SB01 Soil ug/kg	0802-SB02 Soil ug/kg
N-Nitrosodimethylamine								
Phenol								
Bis(2-chloroethyl) Ether								
1,3-Dichlorobenzene			29J	26J		27J	28J	
1,4-Dichlorobenzene								
1,2-Dichlorobenzene								
2-Methylphenol								
Bis(2-chloroisopropyl) Ether								
4-Methylphenol								
N-Nitrosodipropylamine								
Hexachloroethane								
Nitrobenzene								
Isophorene								
2-Nitrophenol								
2,4-Dimethylphenol								
Bis(2-chloroethoxy)methane								
2,4-Dichlorophenol								
1,2,4-Trichlorobenzene								
Napthalene								
Hexachlorobutadiene								
4-Chloro-3-methylphenol								
Hexachlorocyclopentadiene								
2,4,6-Trichlorophenol								
2-Chloronapthalene								
Dimethyl Phtalate								
Acenapthylene								
Acenapthene								
2,4-Dinitrophenol								

NOTES:
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SAMPLING DATE: 8/1/88
LAB NAME: AnalytiKEM

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TABLE 1 (CONT'D)

SEMI-VOLATILES Sample Designation Matrix Units	Method Blank Nonaqueous ug/kg	0301-SB01 Soil ug/kg	0301-SB02 Soil ug/kg	0301-SB03 Soil ug/kg	Method Blank Nonaqueous ug/kg	0801-SB01 Soil ug/kg	0802-SB01 Soil ug/kg	0802-SB02 Soil ug/kg
4-Nitrophenol		29J						
2,4-Dinitrotoluene								
2,6-Dinitrotoluene								
Diethyl Phthalate								
4-Chlorophenyl Phenyl Ether								
Flourene								
4,6--Dinitro-2-methylphenol								
N-Nitrosodiphenylamine						25J		
4-Bromophenyl Phenyl Ether								
Hexachlorobenzene								
Pentachlorophenol								
Phenanthrene		120J					24J	
Anthracene		27J						
Dibutyl Phthalate	22J	30J	19J		22J			
Flouranthene		150J					51J	
Benzidine								
Pyrene		190J					50J	
Butylbenzyl Phthalate							32J	
3,3'-Dichlorobenzidine		80J						
Benzo(a)anthracene							32J	
Bis(2-ethylhexyl) Phthalate	18J	96J	47J	51J	18J	83J	100J	99J
Chrysene							35J	
Dioctyl Phthalate		44J						
Benzo(b)flouranthene		57J					44J	
Benzo(k)flouranthene		67J						
Benzo(a)pyrene							25J	
Indeno(1,2,3-cd)pyrene							27J	
Dibenzo(a,h)anthracene								
Benzo(g,h,i)perylene								

NOTES:
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TABLE 1 (CONT'D)

POLYCHLORINATED BIPHENYLS				
Sample Designation	Method Blank	0201-SB01	0201-SB02	0201-SB03
Matrix	Nonaqueous	Soil	Soil	Soil
Units	ug/kg	ug/kg	ug/kg	ug/kg
Aroclor 1016				
Aroclor 1221				
Aroclor 1232				
Aroclor 1242				
Aroclor 1248				
Aroclor 1254				
Aroclor 1260				

NOTES:
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TABLE 1 (CONT'D)

PESTICIDAL COMPOUNDS AND POLYCHLORINATED BIPHENYLS Sample Designation Matrix Units	Method Blank Nonaqueous ug/kg	0301-SB01 Soil ug/kg	0301-SB02 Soil ug/kg	0301-SB03 Soil ug/kg	Method Blank Nonaqueous ug/kg	0801-SB01 Soil ug/kg	0802-SB01 Soil ug/kg	0802-SB02 Soil ug/kg
alpha-BHC								
beta-BHC								
delta-BHC								
gamma-BHC (Lindane)								
Heptachlor								
Aldrin								
Heptachlor Epoxide								
Endosulfan I								
Dieldrin								
4,4'DDE								
Endrin								
Endosulfan II								
4,4'DDD								
Endosulfan Sulfate								
4,4'DDT								
Endrin Aldehyde								
Chlordane								
Toxaphene								
Aroclor 1016								
Aroclor 1221								
Aroclor 1232								
Aroclor 1242								
Aroclor 1248							37J	
Aroclor 1254								
Aroclor 1260								

NOTES:
Blank space - Compound analyzed for but not detected
J - Compound was detected at a level below the practical quantitation limit. The level reported is approximate

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TABLE 1 (CONT'D)

METALS Sample Designation Matrix Units	Method Blank Nonaqueous ug/kg	0201-SB01 Soil ug/kg	0201-SB02 Soil ug/kg	0201-SB03 Soil ug/kg	0301-SB01 Soil ug/kg	0301-SB02 Soil ug/kg	0301-SB03 Soil ug/kg
Antimony, total		2100					
Arsenic, total		1400	5100	12000	5200	2500	1800
Beryllium, total		1200	890	740	750	390	400J
Cadmium, total		2900	2800	1500	2100	690	710J
Chromium, total		17000	25000	8600	13000	11000	13000
Copper, total		10000	9300	5100	6100	2600J	3000J
Lead, total		20000	21000	8900J	14000		
Mercury, total				220J			
Nickel, total		7300	7400	3500J	5100	3700J	3100J
Selenium, total				450J			
Silver, total		2100J	1600J	1300J	1100J	1200J	1300J
Thallium, total							
Zinc, total		28000	63000	1000	24000	7400	12000

NOTES:
Blank space - Compound analyzed for but not detected
J - Compound was detected at a level below the practical quantitation limit. The level reported is approximate

SITE NAME: MONSANTO COMPANY
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SAMPLING DATE: 8/1/88
LAB NAME: AnalytiKEM

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TABLE 1 (CONT'D)

METALS Sample Designation Matrix Units	Method Blank Nonaqueous ug/kg	0801-SB01 Soil ug/kg	0802-SB01 Soil ug/kg	0802-SB02 Soil ug/kg
Antimony, total				
Arsenic, total		2800	12000	7100
Beryllium, total		530	830	780
Cadmium, total		1700	1300	1600
Chromium, total		11000	9500	14000
Copper, total		4900	7700	5200
Lead, total		11000	21000	11000
Mercury, total				
Nickel, total		4500	6600	4700
Selenium, total				
Silver, total		1100J	1200J	
Thallium, total				
Zinc, total		14000	23000	7500

NOTES:
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LAB NAME: AnalytiKEM

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TABLE 1 (CONT'D)

VOLATILES Sample Designation Matrix Units	Method Blank 1 Nonaqueous ug/kg	Method Blank 1 Nonaqueous ug/kg	1201-SB01 Soil ug/kg	0101-SB01 Soil ug/kg	0101-SB02 Soil ug/kg	1001-SB01 Soil ug/kg	Method Blank Aqueous ug/l	0801-WB01 * Aqueous ug/l	0503-WB01 * Aqueous ug/l
Chloromethane									
Bromomethane									
Vinyl Chloride									
Chloroethane									
Methylene Chloride	120J	120J	740					5.0J	5.0J
1,1-Dichloroethene									
1,1-Dichloroethane									
trans-1,2-Dichloroethene									
Chloroform									
1,2-Dichloroethane									
1,1,1-Trichloroethane						7600			
Carbon Tetrachloride									
Bromodichloromethane									
1,2-Dichloropropane									
trans-1,3-Dichloropropene									
Trichloroethene									
Dibromochloromethane									
1,1,2-Trichloroethane									
Benzene									
cis-1,3-Dichloropropene									
2-Chloroethyl Vinyl Ether									
Bromoform									
Tetrachloroethene						7300			
1,1,2,2-Tetrachloroethane									
Toluene	270J	270J	900						
Chlorobenzene									
Ethylbenzene									
m-Xylene									
o,p-Xylene									

NOTES:
Blank space - Compound analyzed for but not detected
J - Compound was detected at a level below the practical quantitation limit. The level reported is approximate
* - denotes Field Blank

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SITE NAME: MONSANTO COMPANY
TDD#: 02-9005-07
SAMPLING DATE: 8/2/88
LAB NAME: AnalytiKEM

TEST REPORT NO. A16918

TABLE 1 (CONT'D)

VOLATILES Sample Designation Matrix Units	Method Blank 2 Nonaqueous ug/kg	1001-SB02 Soil ug/kg	1002-SB01 Soil ug/kg	1002-SB02 Soil ug/kg	Method Blank Nonaqueous ug/kg	0901-SB01 Soil ug/kg	0901-SB02 Soil ug/kg
Chloromethane							
Bromomethane							
Vinyl Chloride							
Chloroethane							
Methylene Chloride		210J					180J
1,1-Dichloroethene							
1,1-Dichloroethane							
trans-1,2-Dichloroethene							
Chloroform							
1,2-Dichloroethane							
1,1,1-Trichloroethane							
Carbon Tetrachloride							
Bromodichloromethane							
1,2-Dichloropropane							
trans-1,3-Dichloropropene							
Trichloroethene							
Dibromochloromethane							
1,1,2-Trichloroethane							
Benzene							
cis-1,3-Dichloropropene							
2-Chloroethyl Vinyl Ether							
Bromoform							
Tetrachloroethene							
1,1,2,2-Tetrachloroethane							
Toluene		620					
Chlorobenzene							
Ethylbenzene							
m-Xylene							
o,p-Xylene							

NOTES:
Blank space - Compound analyzed for but not detected
J - Compound was detected at a level below the practical quantitation limit. The level reported is approximate

SITE NAME: MONSANTO COMPANY
TDD#: 02-9005-07
SAMPLING DATE: 8/2/88
LAB NAME: AnalytiKEM

TEST REPORT NO. A16918

TABLE 1 (CONT'D)

SEMI-VOLATILES Sample Designation Matrix Units	Method Blank Aqeous ug/l	1401-SW01 Aqueous ug/l
N-Nitrosodimethylamine		
Bis(2-chloroethyl) Ether		
1,3-Dichlorobenzene		
1,4-Dichlorobenzene		
1,2-Dichlorobenzene		
Bis(2-chloroisopropyl) Ether		
N-Nitrosodipropylamine		
Hexachloroethane		
Nitrobenzene		
Isophorene		
Bis(2-chloroethoxy)methane		
1,2,4-Trichlorobenzene		
Napthalene		
Hexachlorocyclopentadiene		
2-Chloronapthalene		
Dimethyl Phtalate		
Acenapthylene		
Acenapthene		

NOTES:
Blank space - Compound analyzed for but not detected
J - Compound was detected at a level below the practical quantitation limit. The level reported is approximate

SITE NAME: MONSANTO COMPANY
TDD#: 02-9005-07
SAMPLING DATE: 8/2/88
LAB NAME: AnalytiKEM

TEST REPORT NO. A16918

TABLE 1 (CONT'D)

SEMI-VOLATILES Sample Designation Matrix Units	Method Blank Aqueous ug/l	1401-SW01 Aqueous ug/l
2,4-Dinitrotoluene		
2,6-Dinitrotoluene		
Diethyl Phthalate		
4-Chlorophenyl Phenyl Ether		
Flourene		
N-Nitrosodiphenylamine		
4-Bromophenyl Phenyl Ether		
Hexachlorobenzene		
Phenanthrene		0.5J
Anthracene		
Dibutyl Phthalate		
Flouranthene		0.8J
Benzidine		
Pyrene		0.6J
Butylbenzyl Phthalate		
3,3'-Dichlorobenzidine		
Benzo(a)anthracene		
Bis(2-ethylhexyl) Phthalate		19
Chrysene		
Dioctyl Phthalate		
Benzo(b)flouranthene		
Benzo(k)flouranthene		
Benzo(a)pyrene		
Indeno(1,2,3-cd)pyrene		
Dibenzo(a,h)anthracene		
Benzo(g,h,i)perylene		

NOTES:
Blank space - Compound analyzed for but not detected
J - Compound was detected at a level below the practical quantitation limit. The level reported is approximate

SITE NAME: MONSANTO COMPANY
TDD#: 02-9005-07
SAMPLING DATE: 8/2/88
LAB NAME: AnalytiKEM

TEST REPORT NO. A16918

TABLE 1 (CONT'D)

SEMI-VOLATILES Sample Designation Matrix Units	Method Blank Nonaqueous ug/kg	0504-SB01 Soil ug/kg	1201-SB01 Soil ug/kg	0901-SB01 Soil ug/kg	Method Blank Nonaqueous ug/kg	0901-SB02 Soil ug/kg	0101-SB01 Soil ug/kg	0101-SB02 Soil ug/kg
N-Nitrosodimethylamine								
Phenol								
Bis(2-chloroethyl) Ether								
1,3-Dichlorobenzene						70J		
1,4-Dichlorobenzene								
1,2-Dichlorobenzene								
2-Methylphenol								
Bis(2-chloroisopropyl) Ether								
4-Methylphenol								
N-Nitrosodipropylamine								
Hexachloroethane								
Nitrobenzene								
Isophorene								
2-Nitrophenol								
2,4-Dimethylphenol								
Bis(2-chloroethoxy)methane								
2,4-Dichlorophenol								
1,2,4-Trichlorobenzene								
Napthalene								
Hexachlorobutadiene								
4-Chloro-3-methylphenol								
Hexachlorocyclopentadiene								
2,4,6-Trichlorophenol								
2-Chloronapthalene								
Dimethyl Phtalate								
Acenapthylene								
Acenapthene			1100J					
2,4-Dinitrophenol								

NOTES:
Blank space - Compound analyzed for but not detected
J - Compound was detected at a level below the practical quantitation limit. The level reported is approximate

SITE NAME: MONSANTO CORPORATION
TDD#: 02-9005-07
SAMPLING DATE: 8/2/88
LAB NAME: AnalytiKEM

TEST REPORT NO. A16918

TABLE 1 (CONT'D)

SEMI-VOLATILES Sample Designation Matrix Units	Method Blank Nonaqueous ug/kg	0504-SB01 Soil ug/kg	1201-SB02 Soil ug/kg	0901-SB01 Soil ug/kg	Method Blank Nonaqueous ug/kg	0901-SB02 Soil ug/kg	0101-SB01 Soil ug/kg	0101-SB02 Soil ug/kg
4-Nitrophenol								
2,4-Dinitrotoluene								
2,6-Dinitrotoluene								
Diethyl Phthalate								
4-Chlorophenyl Phenyl Ether								
Flourene								
4,6--Dinitro-2-methylphenol								
N-Nitrosodiphenylamine								48J
4-Bromophenyl Phenyl Ether								
Hexachlorobenzene								
Pentachlorophenol								
Phenanthrene			13000	43J				
Anthracene			3000J					
Dibutyl Phthalate								
Flouranthene			19000	86J				
Benzidine								
Pyrene			17000	71J				21J
Butylbenzyl Phthalate			290J					
3,3'-Dichlorobenzidine								
Benzo(a)anthracene			9300	40J				
Bis(2-ethylhexyl) Phthalate			1600J	110J		80J		33J
Chrysene			13000	52J				
Dioctyl Phthalate								
Benzo(b)flouranthene			5100					
Benzo(k)flouranthene								
Benzo(a)pyrene								
Indeno(1,2,3-cd)pyrene			2000J					
Dibenzo(a,h)anthracene								
Benzo(g,h,i)perylene			4300					

NOTES:
Blank space - Compound analyzed for but not detected
J - Compound was detected at a level below the practical quantitation limit. The level reported is approximate

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SITE NAME: MONSANTO COMPANY
TDD#: 02-9005-07
SAMPLING DATE: 8/2/88
LAB NAME: AnalytiKEM

TEST REPORT NO. A16918

TABLE 1 (CONT'D)

SEMI-VOLATILES Sample Designation Matrix Units	Method Blank Nonaqueous ug/kg	1001-SB01 Soil ug/kg	1001-SB02 Soil ug/kg	1002-SB01 Soil ug/kg	Method Blank Nonaqueous ug/kg	1002-SB02 Soil ug/kg	0801-WB01 * Aqueous ug/l	0502-SB01 Soil ug/kg
N-Nitrosodimethylamine								
Phenol			62J	1900				
Bis(2-chloroethyl) Ether								
1,3-Dichlorobenzene			34J					
1,4-Dichlorobenzene			30J	130J				
1,2-Dichlorobenzene				43J				
2-Methylphenol				25J				
Bis(2-chloroisopropyl) Ether								
4-Methylphenol		2800		2000		83J		
N-Nitrosodipropylamine								
Hexachloroethane								
Nitrobenzene								
Isophorene								
2-Nitrophenol								
2,4-Dimethylphenol				50J				
Bis(2-chloroethoxy)methane								
2,4-Dichlorophenol								
1,2,4-Trichlorobenzene			270J	2100		470		
Napthalene		830		40J				
Hexachlorobutadiene								
4-Chloro-3-methylphenol								
Hexachlorocyclopentadiene								
2,4,6-Trichlorophenol								
2-Chloronapthalene								
Dimethyl Phtalate								
Acenapthylene								
Acenapthene								
2,4-Dinitrophenol								

NOTES:
Blank space - Compound analyzed for but not detected
J - Compound was detected at a level below the practical quantitation limit. The level reported is approximate
* - Denotes Field Blank

SITE NAME: MONSANTO COMPANY
TDD#: 02-9005-07
SAMPLING DATE: 8/2/88
LAB NAME: AnalytiKEM

TEST REPORT NO. A16918

TABLE 1 (CONT'D)

SEMI-VOLATILES Sample Designation Matrix Units	Method Blank Nonaqueous ug/kg	1001-SB01 Soil ug/kg	1001-SB02 Soil ug/kg	1002-SB01 Soil ug/kg	Method Blank Nonaqueous ug/kg	1002-SB02 Soil ug/kg	0801-WB01 * Aqueous ug/l	0502-SB01 Soil ug/kg
4-Nitrophenol								
2,4-Dinitrotoluene								
2,6-Dinitrotoluene								
Diethyl Phthalate								
4-Chlorophenyl Phenyl Ether								
Flourene								
4,6--Dinitro-2-methylphenol								
N-Nitrosodiphenylamine								
4-Bromophenyl Phenyl Ether								
Hexachlorobenzene								
Pentachlorophenol								
Phenanthrene								
Anthracene								
Dibutyl Phthalate			21J					
Flouranthene								
Benzidine								
Pyrene								
Butylbenzyl Phthalate								
3,3'-Dichlorobenzidine								
Benzo(a)anthracene								
Bis(2-ethylhexyl) Phthalate			57J	86J				71J
Chrysene								
Dioctyl Phthalate				24J				
Benzo(b)flouranthene								
Benzo(k)flouranthene								
Benzo(a)pyrene								
Indeno(1,2,3-cd)pyrene								
Dibenzo(a,h)anthracene								
Benzo(g,h,i)perylene								

NOTES:
Blank space - Compound analyzed for but not detected
J - Compound was detected at a level below the practical quantitation limit. The level reported is approximate
* - Denotes Field Blank

SITE NAME: MONSANTO COMPANY
TDD#: 02-9005-07
SAMPLING DATE: 8/2/88
LAB NAME: AnalytiKEM

TEST REPORT NO. A16918

TABLE 1 (CONT'D)

SEMI-VOLATILES Sample Designation Matrix Units	Method Blank Nonaqueous ug/kg	0503-SB01 Soil ug/kg	0503-WB01 * Aqueous ug/l
N-Nitrosodimethylamine			
Phenol			
Bis(2-chloroethyl) Ether			
1,3-Dichlorobenzene			
1,4-Dichlorobenzene			
1,2-Dichlorobenzene			
2-Methylphenol			
Bis(2-chloroisopropyl) Ether			
4-Methylphenol			
N-Nitrosodipropylamine			
Hexachloroethane			
Nitrobenzene			
Isophorene			
2-Nitrophenol			
2,4-Dimethylphenol			
Bis(2-chloroethoxy)methane			
2,4-Dichlorophenol			
1,2,4-Trichlorobenzene			
Napthalene			
Hexachlorobutadiene			
4-Chloro-3-methylphenol			
Hexachlorocyclopentadiene			
2,4,6-Trichlorophenol			
2-Chloronapthalene			
Dimethyl Phtalate			
Acenapthylene			
Acenapthene			
2,4-Dinitrophenol			

NOTES:
Blank space - Compound analyzed for but not detected
J - Compound was detected at a level below the practical quantitation limit. The level reported is approximate
* - Denotes Field Blank

SITE NAME: MONSANTO COMPANY
TDD#: 02-9005-07
SAMPLING DATE: 8/2/88
LAB NAME: AnalytiKEM

TEST REPORT NO. A16918

TABLE 1
(CONT'D)

SEMI-VOLATILES Sample Designation Matrix Units	Method Blank Nonaqueous ug/kg	0503-SB01 Soil ug/kg	0503-WB01 * Aqueous ug/l
4-Nitrophenol			
2,4-Dinitrotoluene			
2,6-Dinitrotoluene			
Diethyl Phthalate			
4-Chlorophenyl Phenyl Ether			
Flourene			
4,6--Dinitro-2-methylphenol			
N-Nitrosodiphenylamine			
4-Bromophenyl Phenyl Ether			
Hexachlorobenzene			
Pentachlorophenol			
Phenanthrene			
Anthracene			
Dibutyl Phthalate		35J	
Flouranthene			
Benzidine			
Pyrene		180J	
Butylbenzyl Phthalate			
3,3'-Dichlorobenzidine			
Benzo(a)anthracene			
Bis(2-ethylhexyl) Phthalate			
Chrysene			
Dioctyl Phthalate		3700	
Benzo(b)flouranthene			
Benzo(k)flouranthene			
Benzo(a)pyrene			
Indeno(1,2,3-cd)pyrene			
Dibenzo(a,h)anthracene			
Benzo(g,h,i)perylene			

NOTES:
Blank space - Compound analyzed for but not detected
J - Compound was detected at a level below the practical quantitation limit. The level reported is approximate
* - Denotes Field Blank

SITE NAME: MONSANTO COMPANY
TDD#: 02-9005-07
SAMPLING DATE: 8/2/88
LAB NAME: AnalytiKEM

TEST REPORT NO. A16918

**TABLE 1
(CONT'D)**

POLYCHLORINATED BIPHENYLS Sample Designation Matrix Units	Method Blank Aqueous ug/l	1401-SW01 Aqueous ug/l
Aroclor 1016		
Aroclor 1221		
Aroclor 1232		
Aroclor 1242		
Aroclor 1248		
Aroclor 1254		
Aroclor 1260		

NOTES:
Blank space - Compound analyzed for but not detected
J - Compound was detected at a level below the practical quantitation limit. The level reported is approximate

SITE NAME: MONSANTO CORPORATION
TDD#: 02-9005-07
SAMPLING DATE: 8/2/88
LAB NAME: AnalytiKEM

TEST REPORT NO. A16918

TABLE 1 (CONT'D)

PESTICIDAL COMPOUNDS AND POLYCHLORINATED BIPHENYLS Sample Designation Matrix Units	Method Blank Nonaqueous ug/kg	0504-SB01 Soil ug/kg	1201-SB01 Soil ug/kg	0901-SB01 Soil ug/kg	Method Blank Nonaqueous ug/kg	0901-SB02 Soil ug/kg	0101-SB01 Soil ug/kg	0101-SB02 Soil ug/kg
alpha-BHC								
beta-BHC								
delta-BHC								
gamma-BHC (Lindane)								
Heptachlor								
Aldrin								
Heptachlor Epoxide								
Endosulfan I								
Dieldrin								
4,4'DDE								
Endrin								
Endosulfan II								
4,4'DDD								
Endosulfan Sulfate								
4,4'DDT								
Endrin Aldehyde								
Chlordane								
Toxaphene								
Aroclor 1016								
Aroclor 1221								
Aroclor 1232								
Aroclor 1242								
Aroclor 1248								
Aroclor 1254								
Aroclor 1260								

NOTES:
Blank space - Compound analyzed for but not detected
J - Compound was detected at a level below the practical quantitation limit. The level reported is approximate

SITE NAME: MONSANTO COMPANY
TDD#: 02-9005-07
SAMPLING DATE: 8/2/88
LAB NAME: AnalytiKEM

TEST REPORT NO. A16918

TABLE 1 (CONT'D)

PESTICIDAL COMPOUNDS AND POLYCHLORINATED BIPHENYLS Sample Designation Matrix Units	Method Blank Nonaqueous ug/kg	1001-SB01 Soil ug/kg	1001-SB02 Soil ug/kg	1002-SB01 Soil ug/kg	Method Blank Nonaqueous ug/kg	1002-SB02 Soil ug/kg	0801-WB01 * Aqueous ug/l	0502-SB01 Soil ug/kg
alpha-BHC								
beta-BHC								
delta-BHC								
gamma-BHC (Lindane)								
Heptachlor								
Aldrin								
Heptachlor Epoxide								
Endosulfan I								
Dieldrin								
4,4'DDE								
Endrin								
Endosulfan II								
4,4'DDD								
Endosulfan Sulfate								
4,4'DDT								
Endrin Aldehyde								
Chlordane								
Toxaphene								
Aroclor 1016								
Aroclor 1221								
Aroclor 1232								
Aroclor 1242		79000	660	6600		1800		
Aroclor 1248								
Aroclor 1254								
Aroclor 1260								

NOTES:
Blank space - Compound analyzed for but not detected
J - Compound was detected at a level below the practical quantitation limit. The level reported is approximate
* - Denotes Field Blank

SITE NAME: MONSANTO COMPANY
TDD#: 02-9005-07
SAMPLING DATE: 8/2/88
LAB NAME: AnalytiKEM

TEST REPORT NO. A16918

TABLE 1 (CONT'D)

PESTICIDAL COMPOUNDS AND POLYCHLORINATED BIPHENYLS Sample Designation Matrix Units	Method Blank Nonaqueous ug/kg	0503-SB01 Soil ug/kg	0503-WB01 * Aqueous ug/l
alpha-BHC			
beta-BHC			
delta-BHC			
gamma-BHC (Lindane)			
Heptachlor			
Aldrin			
Heptachlor Epoxide			
Endosulfan I			
Dieldrin			
4,4'DDE			
Endrin			
Endosulfan II			
4,4'DDD			
Endosulfan Sulfate			
4,4'DDT			
Endrin Aldehyde			
Chlordane			
Toxaphene			
Aroclor 1016			
Aroclor 1221			
Aroclor 1232			
Aroclor 1242		240J	
Aroclor 1248			
Aroclor 1254			
Aroclor 1260			

NOTES:
Blank space - Compound analyzed for but not detected
J - Compound was detected at a level below the practical quantitation limit. The level reported is approximate
* - Denotes Field Blank

SITE NAME: MONSANTO COMPANY
TDD#: 02-9005-07
SAMPLING DATE: 8/2/88
LAB NAME: AnalytiKEM

TEST REPORT NO. A16918

TABLE 1 (CONT'D)

METALS Sample Designation Matrix Units	Method Blank Nonaqueous ug/kg	0504-SB01 Soil ug/kg	1201-SB01 Soil ug/kg	0901-SB01 Soil ug/kg	0901-SB02 Soil ug/kg	0101-SB01 Soil ug/kg	0101-SB02 Soil ug/kg	1001-SB01 Soil ug/kg
Antimony, total			510J					
Arsenic, total		15000	2500	12000	4000	13000	20000	3800
Beryllium, total				1100				1200
Cadmium, total		8400	6200			10000	13000	
Chromium, total		36000	86000	16000	18000	40000	42000	18000
Copper, total			160000	14000		51000	65000	
Lead, total			96000	51000				
Mercury, total								
Nickel, total			47000			23000	28000	
Selenium, total								
Silver, total								
Thallium, total								
Zinc, total		48000	170000	29000	22000	81000	77000	35000

NOTES:
Blank space - Compound analyzed for but not detected
J - Compound was detected at a level below the practical quantitation limit. The level reported is approximate

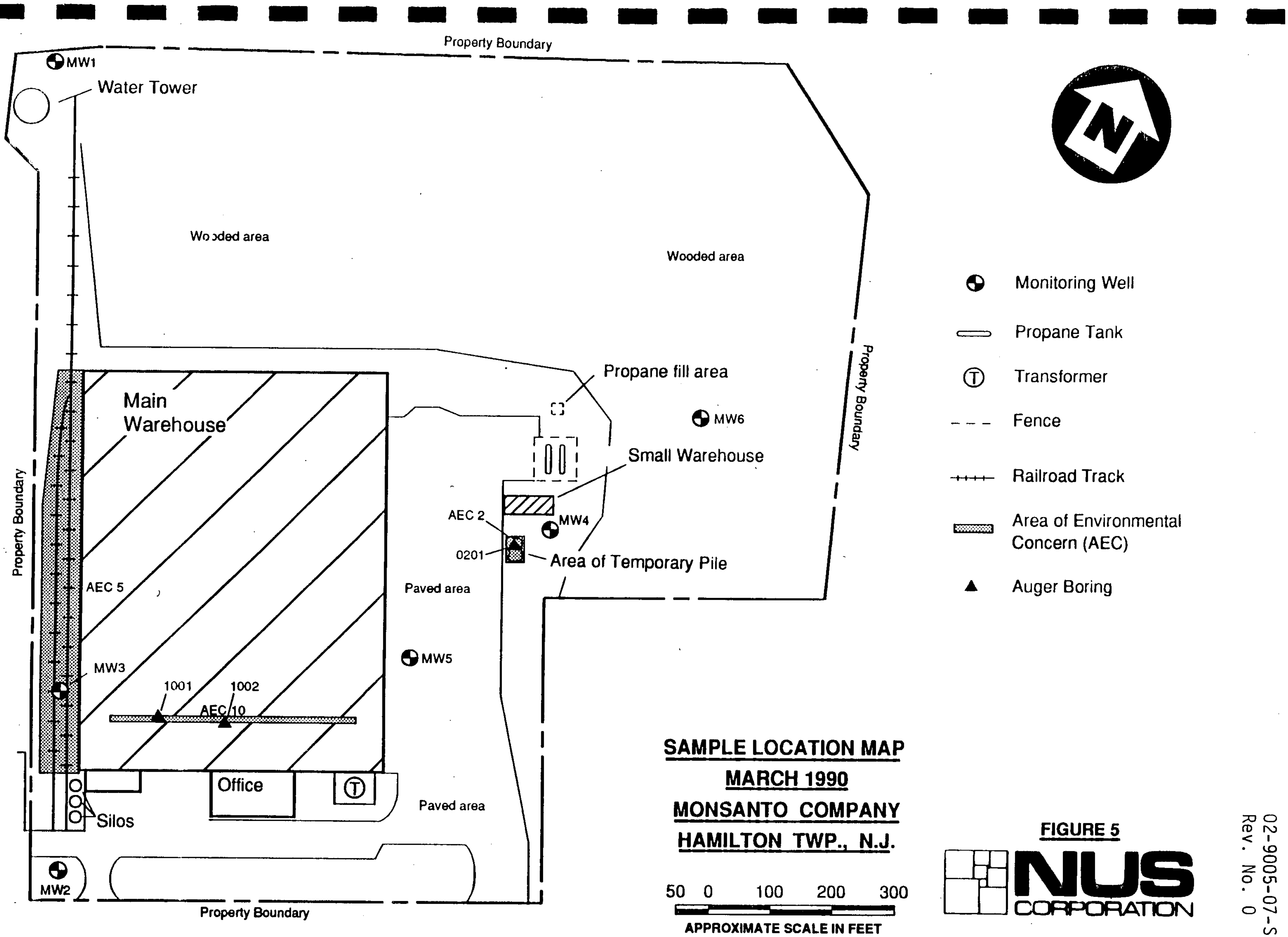
SITE NAME: MONSANTO COMPANY
TDD#: 02-9005-07
SAMPLING DATE: 8/2/88
LAB NAME: AnalytiKEM

TEST REPORT NO. A16918

TABLE 1 (CONT'D)

METALS Sample Designation Matrix Units	Method Blank Nonaqueous ug/kg	1001-SB02 Soil ug/kg	1002-SB01 Soil ug/kg	1002-SB02 Soil ug/kg	0801-WB01 * Aqueous ug/l	0502-SB01 Soil ug/kg	0503-SB01 Soil ug/kg	0503-WB01 * Aqueous ug/l
Antimony, total						2400		
Arsenic, total		14000	3600	46000	2.7J	18000	44000	
Beryllium, total								
Cadmium, total		11000	6000	26000		17000	12000	
Chromium, total		43000	22000	78000		52000	38000	
Copper, total			25000	140000		95000	63000	
Lead, total								
Mercury, total								
Nickel, total				41000		24000		40
Selenium, total								
Silver, total								
Thallium, total								
Zinc, total		62000	38000	120000	75	67000	62000	180

NOTES:
Blank space - Compound analyzed for but not detected
J - Compound was detected at a level below the practical quantitation limit. The level reported is approximate
* - Denotes Field Blank



SAMPLE LOCATION MAP
MARCH 1990
MONSANTO COMPANY
HAMILTON TWP., N.J.

FIGURE 5

NUS CORPORATION

02-9005-07-SI
Rev. No. 0

SITE NAME: MONSANTO CORPORATION
TDD#: 02-9005-07
SAMPLING DATE: 3/1/90
LAB NAME: AnalytiKEM

TEST REPORT NO. A21268

TABLE 2

VOLATILES Sample Designation Matrix Units	Method Blank 1 Nonaqeous ug/kg	Method Blank 1 Nonaqeous ug/kg	1002-PE01 Soil ug/kg	1002-PE02 Soil ug/kg	1002-PE03 Soil ug/kg	1002-PE04 Soil ug/kg	1002-PE05 Soil ug/kg	1001-PE01 Soil ug/kg
Chloromethane								
Bromomethane								
Vinyl Chloride								
Chloroethane								
Methylene Chloride							670	560
1,1-Dichloroethene								
1,1-Dichloroethane								
trans-1,2-Dichloroethene								
Chloroform								
1,2-Dichloroethane								
1,1,1-Trichloroethane							6600	1900
Carbon Tetrachloride								
Bromodichloromethane								
1,2-Dichloropropane								
trans-1,3-Dichloropropene								
Trichloroethene								
Dibromochloromethane								
1,1,2-Trichloroethane								
Benzene								
cis-1,3-Dichloropropene								
2-Chloroethyl Vinyl Ether								
Bromoform								
Tetrachloroethene				220J			5700	1100
1,1,2,2-Tetrachloroethane								
Toluene					280J		510	470
Chlorobenzene								
Ethylbenzene								
m-Xylene								
o,p-Xylene								

NOTES:
Blank space - Compound analyzed for but not detected
J - Compound was detected at a level below the practical quantitation limit. The level reported is approximate

SITE NAME: MONSANTO COMPANY
TDD#: 02-9005-07
SAMPLING DATE: 3/1/90
LAB NAME: AnalytiKEM

TEST REPORT NO. A21268

TABLE 2 (CONT'D)

VOLATILES Sample Designation Matrix Units	Method Blank 2 Nonaqueous ug/kg	Method Blank 2 Nonaqueous ug/kg	1001-PE03 Soil ug/kg	1001-PE04 Soil ug/kg	1001-PE05 Soil ug/kg	0201-PE01 Soil ug/kg	0201-PE03 Soil ug/kg	0201-PE04 Soil ug/kg
Chloromethane								
Bromomethane								
Vinyl Chloride								
Chloroethane								
Methylene Chloride					510			
1,1-Dichloroethene								
1,1-Dichloroethane								
trans-1,2-Dichloroethene								
Chloroform								
1,2-Dichloroethane								
1,1,1-Trichloroethane			740					
Carbon Tetrachloride								
Bromodichloromethane								
1,2-Dichloropropane								
trans-1,3-Dichloropropene								
Trichloroethene								
Dibromochloromethane								
1,1,2-Trichloroethane								
Benzene								
cis-1,3-Dichloropropene								
2-Chloroethyl Vinyl Ether								
Bromoform								
Tetrachloroethene			510	1200	250J			
1,1,2,2-Tetrachloroethane								
Toluene								
Chlorobenzene								
Ethylbenzene								
m-Xylene								
o,p-Xylene								

NOTES:
Blank space - Compound analyzed for but not detected
J - Compound was detected at a level below the practical quantitation limit. The level reported is approximate

SITE NAME: MONSANTO COMPANY
TDD#: 02-9005-07
SAMPLING DATE: 3/1/90
LAB NAME: AnalytiKEM

TEST REPORT NO. A21268

TABLE 2 (CONT'D)

VOLATILES Sample Designation Matrix Units	Method Blank 3 Aqeous ug/l	1001-WB01 * Aqueous ug/l	0214-TB01 * Aqueous ug/l	Method Blank 4 Nonaqueous ug/kg	1001-PE02 Soil ug/kg	0201-PE02 Soil ug/kg	0201-PE05 Soil ug/kg	1001-WC01 Composite Soil ug/kg
Chloromethane								
Bromomethane								
Vinyl Chloride								
Chloroethane								
Methylene Chloride					490	660		
1,1-Dichloroethene								
1,1-Dichloroethane								
trans-1,2-Dichloroethene								
Chloroform								
1,2-Dichloroethane								
1,1,1-Trichloroethane					7900			
Carbon Tetrachloride								
Bromodichloromethane								
1,2-Dichloropropane								
trans-1,3-Dichloropropene								
Trichloroethene								
Dibromochloromethane								
1,1,2-Trichloroethane								
Benzene								
cis-1,3-Dichloropropene								
2-Chloroethyl Vinyl Ether								
Bromoform								
Tetrachloroethene								
1,1,2,2-Tetrachloroethane								
Toluene								
Chlorobenzene								
Ethylbenzene								
m-Xylene								
o,p-Xylene								

NOTES:
Blank space - Compound analyzed for but not detected
J - Compound was detected at a level below the practical quantitation limit. The level reported is approximate
* - Denotes Field Blank

SITE NAME: MONSANTO CORPORATION
TDD#: 02-9005-07
SAMPLING DATE: 3/1/90
LAB NAME: AnalytiKEM

TEST REPORT NO. A21268

TABLE 2 (CONT'D)

SEMI-VOLATILES Sample Designation Matrix Units	Method Blank Nonaqueous ug/kg	0201-PE01 Soil ug/kg	0201-PE02 Soil ug/kg	0201-PE03 Soil ug/kg	Method Blank Nonaqueous ug/kg	0201-PE04 Soil ug/kg	0201-PE05 Soil ug/kg
N-Nitrosodimethylamine							
Bis(2-chloroethyl) Ether							
1,3-Dichlorobenzene							
1,4-Dichlorobenzene							
1,2-Dichlorobenzene							
Bis(2-chloroisopropyl) Ether							
N-Nitrosodipropylamine							
Hexachloroethane							
Nitrobenzene							
Isophorene							
Bis(2-chloroethoxy)methane							
1,2,4-Trichlorobenzene							
Napthalene							
Hexachlorocyclopentadiene							
2-Chloronapthalene							
Dimethyl Phtalate							
Acenapthylene							
Acenapthene							

NOTES:
Blank space - Compound analyzed for but not detected
J - Compound was detected at a level below the practical quantitation limit. The level reported is approximate

SITE NAME: MONSANTO CORPORATION
TDD#: 02-9005-07
SAMPLING DATE: 3/1/90
LAB NAME: AnalytiKEM

TEST REPORT NO. A21268

TABLE 2 (CONT'D)

SEMI-VOLATILES Sample Designation Matrix Units	Method Blank Nonaqueous ug/kg	0201-PE01 Soil ug/kg	0201-PE02 Soil ug/kg	0201-PE03 Soil ug/kg	Method Blank Nonaqueous ug/kg	0201-PE04 Soil ug/kg	0201-PE05 Soil ug/kg
2,4-Dinitrotoluene							
2,6-Dinitrotoluene							
Diethyl Phthalate							
4-Chlorophenyl Phenyl Ether							
Flourene							
N-Nitrosodiphenylamine							
4-Bromophenyl Phenyl Ether							
Hexachlorobenzene							
Phenanthrene							
Anthracene							
Dibutyl Phthalate							
Flouranthene							
Benzidine							
Pyrene							
Butylbenzyl Phthalate							
3,3'-Dichlorobenzidine							
Benzo(a)anthracene							
Bis(2-ethylhexyl) Phthalate			110J			86J	49J
Chrysene							
Dioctyl Phthalate							
Benzo(b)flouranthene							
Benzo(k)flouranthene							
Benzo(a)pyrene							
Indeno(1,2,3-cd)pyrene							
Dibenzo(a,h)anthracene							
Benzo(g,h,i)perylene							

NOTES:
Blank space - Compound analyzed for but not detected
J - Compound was detected at a level below the practical quantitation limit. The level reported is approximate

SITE NAME: MONSANTO CORPORATION
TDD#: 02-9005-07
SAMPLING DATE: 3/1/90
LAB NAME: AnalytiKEM

TEST REPORT NO. A21268

TABLE 2 (CONT'D)

POLYCHLORINATED BIPHENYLS Sample Designation Matrix Units	Method Blank Nonaqueous ug/kg	1002-PE01 Soil ug/kg	1002-PE02 Soil ug/kg	1002-PE03 Soil ug/kg	1002-PE04 Soil ug/kg	1002-PE05 Soil ug/kg	1001-PE01 Soil ug/kg	1001-PE02 Soil ug/kg
Aroclor 1016								
Aroclor 1221								
Aroclor 1232								
Aroclor 1242		22000	680000	5400	100000	520000	3200	120000
Aroclor 1248								
Aroclor 1254		2100J	59000	410	8200	55000	170J	32000J
Aroclor 1260								

NOTES:
Blank space - Compound analyzed for but not detected
J - Compound was detected at a level below the practical quantitation limit. The level reported is approximate

SITE NAME: MONSANTO COMPANY
TDD#: 02-9005-07
SAMPLING DATE: 3/1/90
LAB NAME: AnalytiKEM

TEST REPORT NO. A21268

TABLE 2 (CONT'D)

POLYCHLORINATED BIPHENYLS Sample Designation Matrix Units	Method Blank Nonaqueous ug/kg	1001-PE03 Soil ug/kg	1001-PE04 Soil ug/kg	1001-PE05 Soil ug/kg	1001-WC01 Composite Soil ug/kg	0401-WC01 Composite Soil ug/kg	1000-WC01 Composite Soil ug/kg	1001-WB01 * Aqueous ug/l
Aroclor 1016								
Aroclor 1221								
Aroclor 1232								
Aroclor 1242		830000	79000	20000	53000	400	83000	
Aroclor 1248								
Aroclor 1254		42000	11000	3000J	5400	44J	6700	
Aroclor 1260								

NOTES:
Blank space - Compound analyzed for but not detected
J - Compound was detected at a level below the practical quantitation limit. The level reported is approximate
* - Denotes Field Blank

SITE NAME: MONSANTO CORPORATION
TDD#: 02-9005-07
SAMPLING DATE: 3/1/90
LAB NAME: AnalytiKEM

TEST REPORT NO. A21268

TABLE 2 (CONT'D)

METALS Sample Designation Matrix Units	Method Blank Nonaqueous ug/kg	1002-PE01 Soil ug/kg	1002-PE02 Soil ug/kg	1002-PE03 Soil ug/kg	1002-PE04 Soil ug/kg	1002-PE05 Soil ug/kg	1001-PE01 Soil ug/kg
Arsenic, total		19000	3400	6200	7200	44000	13000
Cadmium, total							

NOTES:
Blank space - Compound analyzed for but not detected
J - Compound was detected at a level below the practical quantitation limit. The level reported is approximate

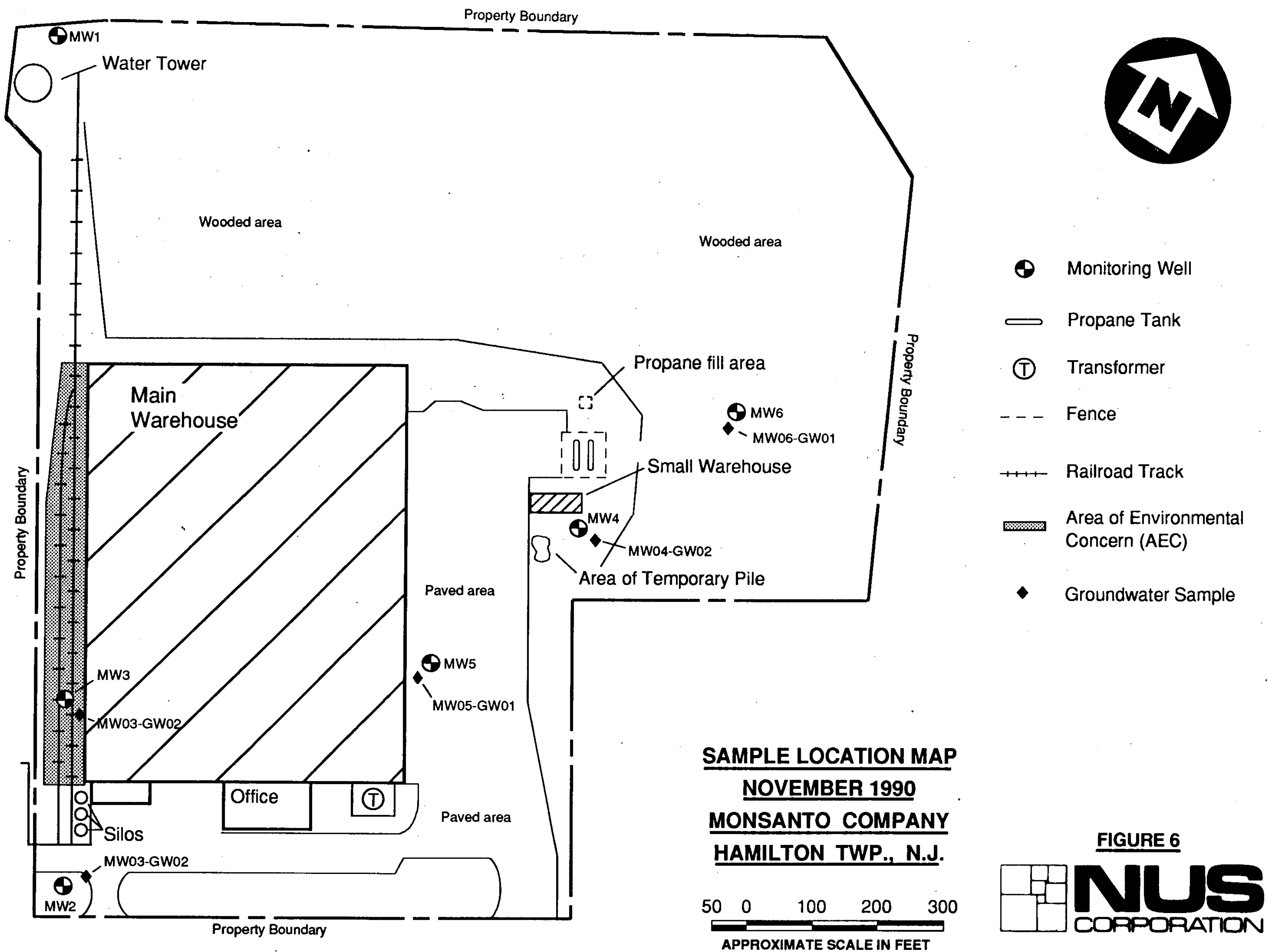
SITE NAME: MONSANTO COMPANY
TDD#: 02-9005-07
SAMPLING DATE: 3/1/90
LAB NAME: AnalytiKEM

TEST REPORT NO. A21268

TABLE 2 (CONT'D)

METALS Sample Designation Matrix Units	1001-PE02 Soil ug/kg	1001-PE03 Soil ug/kg	1001-PE04 Soil ug/kg	1001-PE05 Soil ug/kg	1001-WB01 * Aqueous ug/l
Arsenic, total	4300	5600	4900	22000	
Cadmium, total					

NOTES:
Blank space - Compound analyzed for but not detected
J - Compound was detected at a level below the practical quantitation limit. The level reported is approximate
* - Denotes Field Blank



SAMPLE LOCATION MAP
NOVEMBER 1990
MONSANTO COMPANY
HAMILTON TWP., N.J.

50 0 100 200 300
APPROXIMATE SCALE IN FEET

FIGURE 6

NUS CORPORATION

02-9005-07-SI
Rev. No. 0

SITE NAME: MONSANTO COMPANY
TDD#: 02-9005-07
SAMPLING DATE: 11/1/90
LAB NAME: AnalytiKEM

TEST REPORT NO. A23042

TABLE 3

VOLATILES Sample Designation Matrix Units	Method Blank Aqeous ug/l	MW03-GW02 Aqueous ug/l	MW02-GW02 Aqueous ug/l	MW04-GW02 Aqueous ug/l	Method Blank Aqueous ug/l	MW06-GW01 Aqueous ug/l	MW05-GW01 Aqueous ug/l	FB-901023 *Aqueous ug/l	TB-901023 *Aqueous ug/l
Chloromethane									
Bromomethane									
Vinyl Chloride									
Chloroethane									
Methylene Chloride	1.0 J	2.4 J	0.97 J	1.1 J	1.0 J	1.2 J	1.2 J	5.1 J	3.8 J
1,1-Dichloroethene							11		
1,1-Dichloroethane							12		
trans-1,2-Dichloroethene				35					
Chloroform									
1,2-Dichloroethane									
1,1,1-Trichloroethane				7.0 J		14			
Carbon Tetrachloride									
Bromodichloromethane									
1,2-Dichloropropane									
trans-1,3-Dichloropropene									
Trichloroethene				18					
Dibromochloromethane									
1,1,2-Trichloroethane									
Benzene									
cis-1,3-Dichloropropene									
2-Chloroethyl Vinyl Ether									
Bromoform									
Tetrachloroethene				89		4.1 J		0.91 J	
1,1,2,2-Tetrachloroethane								1.2 J	
Toluene								1.3 J	
Chlorobenzene								1.5 J	
Ethylbenzene								1.1 J	
m-Xylene									
o,p-Xylene									

NOTES:
Blank space - Compound analyzed for but not detected
J - Compound was detected at a level below the practical quantitation limit. The level reported is approximate
* - Denotes Field Blank

PART IV: HAZARD ASSESSMENT

GROUNDWATER ROUTE

1. **Describe the likelihood of a release of contaminant(s) to the groundwater as follows: observed release, suspected release, or none. Identify contaminants detected or suspected and provide a rationale for attributing them to the site. For observed release, define the supporting analytical evidence.**

A release to groundwater is observed. The on-site monitoring wells are screened in a surficial aquifer with sediment types characteristic of gravel to a medium coarse sand, interbedded with minor beds of silty sand. General shallow groundwater flow is north-northeast toward Back Creek. The Merchantville Clay underlies the shallow aquifer and ranges from 50-60 feet in thickness and possesses a permeability of 10^{-7} to 10^{-10} cm/sec. Analytical results from March 1990 sampling indicate a release of volatile organics to shallow groundwater. Trans-1,2-Dichloroethene, 1,1,1-trichloroethane, trichloroethene, and tetrachloroethene were found in monitoring well No. 4 at 61 micrograms per liter (ug/L), 26 ug/L, 61 ug/L, and 250 ug/L, respectively. Monitoring well No. 4 is a downgradient well and no levels of contamination were reported in the upgradient and the other monitoring wells on site. Two additional wells were installed on September 8, 1990; monitoring well No. 5 was installed directly east of the main warehouse and monitoring well No. 6 was installed north-northeast of monitoring well No. 4, providing a further downgradient representation. Analytical results from November 1990 indicate 1,1-Dichloroethane and 1,1-Dichloroethene in monitoring well No. 5 at concentrations of 12 ug/L and 11 ug/L, respectively. 1,1,1-trichloroethane was found in monitoring well No. 6 at a concentration of 14 ug/L. Monitoring well No. 4 again indicated the presence of volatile organics. Trans-1,2-Dichloroethene, trichloroethene, and tetrachloroethene were found at concentrations of 35 ug/L, 18 ug/L and 89 ug/L, respectively. The presence of part of the volatile organics in the surficial aquifer can possibly be attributed to chemical sorbent materials that were stored temporarily on the ground south-southwest and upgradient of monitoring wells Nos. 4 and 6. No contaminants were detected in upgradient monitoring well No.2.

Ref. Nos. 12, 13, 14

2. **Describe the aquifer of concern; include information such as depth, thickness, geologic composition, areas of karst terrain, permeability, overlying strata, confining layers, interconnections, discontinuities, depth to water table, groundwater flow direction.**

The aquifer of concern is the Raritan Formation consisting of predominantly light colored sands and clays which vary rapidly in color, sorting, and grain size, both vertically and horizontally, throughout their thickness. The Magothy Formation rests disconformably above the Raritan, and ranges from 25-125 feet of fine white sands and clays characterized by mica and carbonized wood. The sands of the Magothy and Raritan Formations are so interconnected that the two units act as a single aquifer. The depth to the water table varies from approximately 57 to 61 feet. Groundwater flows north-northeast, toward Back Creek, with a gradient of about 0.005 feet/foot. Approximately 70 to over 100 feet of black clays of the Merchantville and of the overlying Woodbury Formations are found above the Magothy in a band from 2.5 to 3 miles wide, extending from Yardville and Crosswicks through Robbinsville and Windsor to and beyond Hightstown. The Raritan Formation along Rte. 130 is made up of coarser, thick, well-sorted sands. The Merchantville and Woodbury Clays underlie these sands. The Merchantville is a black glauconitic micaceous clay from 50 to 60 feet thick, with a permeability of 10^{-7} to 10^{-10} cm/sec, which rests disconformably on the Magothy. The Woodbury Clay is also black and about 50 feet thick, but is non-glauconitic clay. It is conformable with the Merchantville below and the Englishtown Formation above.

Ref. No. 9

3. **Is a designated well head protection area within 4 miles of the site?**

   A designated well head protection area does not exist within 4 miles of the site.

   Ref. No. 8

4. **What is the depth from the lowest point of waste disposal/storage to the highest seasonal level of the saturated zone of the aquifer of concern?**

   The depth from the lowest point of waste disposal/storage to the highest level of the saturated zone of the aquifer of concern is 0 feet. Contamination from on-site waste exists in the shallow groundwater.

   Ref. Nos. 12, 17

5. **What is the permeability value of the least permeable continuous intervening stratum between the ground surface and the aquifer of concern?**

   The least permeable continuous intervening stratum between the ground surface and the aquifer of concern is the Merchantville Clay, which possesses a permeability value of 10^{-7} to 10^{-10} cm/sec.

   Ref. Nos. 9, 11

6. **What is the net precipitation for the area?**

   The net annual precipitation for the area is approximately 17.64 inches.

   Ref. No. 6

7. **What is the distance to and depth of the nearest well that is currently used for drinking purposes?**

   The distance to the nearest well that is currently used for drinking purposes is approximately 1,900 feet. The depth of this well is 123 feet.

   Ref. Nos. 16, 18

8. **If a release to groundwater is observed or suspected, determine the number of people that obtain drinking water from wells that are documented or suspected to be located within the contamination boundary of the release.**

   There are no wells providing drinking water that are documented or suspected to be located within the contamination boundary of the release.

   Ref. Nos. 13, 14, 16, 18

9. **Identify the population served by wells located within 4 miles of the site that draw from the aquifer of concern.**

Distance	Population
0 - $\frac{1}{4}$ mi	0
>$\frac{1}{4}$ - $\frac{1}{2}$ mi	4
>$\frac{1}{2}$ - 1 mi	0
>1 - 2 mi	8,277
>2 - 3 mi	8,322
>3 - 4 mi	57

Ref. Nos. 16, 18, 20, 21

10. **Identify uses of groundwater within 4 miles of the site (i.e. private drinking source, municipal source, commercial, irrigation, unuseable).**

Groundwater within 4 miles of the site is used for public, commercial, industrial, institutional, irrigational, and domestic supply.

Ref. Nos. 16, 18, 20

SURFACE WATER ROUTE

11. **Describe the likelihood of a release of contaminant(s) to surface water as follows: observed release, suspected release, or none. Identify contaminants detected or suspected and provide a rationale for attributing them to the site. For observed release, define the supporting analytical evidence.**

A release of contaminants to surface water is suspected. Contamination exists in the shallow aquifer (6-12 ft) and the nearest downslope surface water is Back Creek, approximately 400 feet northeast of the site property line. Groundwater flow is north-northeast, and it is probable that the aquifer discharges to Back Creek.

Ref. Nos. 9, 14, 17, 20

12. **Identify the nearest downslope surface water. If possible, include a description of possible surface drainage patterns from the site.**

The nearest downslope surface water is Back Creek. There is no defined pathway for surface drainage from the site.

Ref. Nos. 16, 17

13. **What is the distance to the nearest downslope surface water? Measure the distance along a course that runoff can be expected to follow.**

The distance to the nearest downslope surface water is approximately 400 feet.

Ref. No. 16

14. **Determine the floodplain that the site is located within.**

The site is outside a 500-year floodplain.

Ref. No. 7

15. **What is the 2-year 24-hour rainfall?**

The 2-year 24-hour rainfall is approximately 3.5 inches.

Ref. No. 5

16. **Identify drinking water intakes in surface waters within 15 miles downstream of the site. For each intake identify: the distance from the point of surface water entry, population served, and stream flow at the intake location.**

There are no drinking water intakes in surface waters within 15 miles downstream of the site.

Ref. Nos. 3, 4, 16

17. **Identify fisheries that exist within 15 miles downstream of the point of surface water entry. For each fishery specify the following information:**

Fishery	Water Body Type	Flow (cfs)
Delaware River	River	>10,000

Ref. No. 16

18. **Identify sensitive environments that exist within 15 miles of the point of surface water entry. For each sensitive environment specify the following:**

There are no sensitive environments within 15 miles of the point of surface water entry.

Ref. No. 16

19. **If a release to surface water is observed or suspected, identify any intakes, fisheries, and sensitive environments from question Nos. 16-18 that are or may be located within the contamination boundary of the release.**

There is no data that indicates a release from the facility to surface water.

Ref. Nos. 12, 13, 14, 17

SOIL EXPOSURE PATHWAY

20. **Determine the number of people that occupy residences or attend school or day care on or within 200 feet of the site property.**

There are no residences, schools, or day care centers on or within 200 feet of the site property.

Ref. No. 17

21. **Determine the number of people that work on or within 200 feet of the site property.**

There are no people that work on or within 200 feet of the site property.

Ref. No. 17

22. **Identify terrestrial sensitive environments on or within 200 feet of the site property.**

There are no terrestrial sensitive environments on or within 200 feet of the site property.

Ref. No. 17

AIR ROUTE

23. Describe the likelihood of release of contaminants to air as follows: observed release, suspected release, or none. Identify contaminants detected or suspected and provide a rationale for attributing them to the site. For observed release define the supporting analytical evidence.

There is little potential for a release of contaminants to the air due to the nature of the waste materials deposited on site. These materials consisted primarily of waste oil, which was deposited surficially.

Ref. Nos. 13, 14, 17

24. Determine populations that reside within 4 miles of the site.

Distance	Population
0 - $\frac{1}{4}$ mi	0
>$\frac{1}{4}$ - $\frac{1}{2}$ mi	235
>$\frac{1}{2}$ - 1 mi	2,604
>1 - 2 mi	14,843
>2 - 3 mi	23,877
>3 - 4 mi	24,702

Ref. Nos. 2, 16

25. Identify sensitive environments and wetlands acreage within $\frac{1}{2}$ mile of the site.

There are no known sensitive environments or wetlands acreage within $\frac{1}{2}$ mile of the site.

Ref. No. 16

26. If a release to air is observed or suspected, determine the number of people that reside or are suspected to reside within the area of air contamination from the release.

A release to air has not been documented in background information and is not suspected.

Ref. Nos. 12, 13, 14, 17

27. If a release to air is observed or suspected, identify any sensitive environments, listed in question No. 25, that are or may be located within the area of air contamination from the release.

A release to air has not been documented in background information and is not suspected.

Ref. Nos. 12, 13, 14, 17

ATTACHMENT 1

EXHIBIT A

PHOTOGRAPH LOG

MONSANTO CORPORATION
HAMILTON TOWNSHIP, NEW JERSEY

ON-SITE RECONNAISSANCE: JUNE 5, 1991

MONSANTO CORPORATION
HAMILTON TOWNSHIP, NEW JERSEY
JUNE 5, 1991

PHOTOGRAPH INDEX

ALL PHOTOGRAPHS WERE TAKEN BY ANTHONY J. BONASERA

Photo Number	Description	Time
1P-1	View looking south at monitoring well No. 2.	0926
1P-2,3	Panoramic view looking north at the western side of the main warehouse.	0930
1P-4,5	Panoramic view looking west at the transformer area and the southern end of the office building.	0935
1P-6	View looking east at monitoring well in parking lot, directly east of the main warehouse.	0950
1P-7	View looking north at excavated material. Monitoring well No. 4 in background.	1000
1P-8,9	Panoramic view looking southwest at south eastern side of main warehouse.	1005
1P-10	View looking west at north eastern side of the main warehouse.	1005
1P-11	View looking north of fenced in propane tank.	1010
1P-12	View looking east at propane fill pipe area.	1015
1P-13	View looking west at the northern end of the main warehouse.	1020
1P-14	View looking north at water tank.	1025
1P-15	View of monitoring well between rail tracks, directly west of the main warehouse.	1030

MONSANTO CORPORATION, HAMILTON TOWNSHIP, NEW JERSEY

1P-1 June 5, 1991 0926
View looking south at monitoring well No. 2.

MONSANTO CORPORATION, HAMILTON TOWNSHIP, NEW JERSEY

1P-2,3 June 5, 1991 0930
Panoramic view looking north at the western side of the main warehouse.

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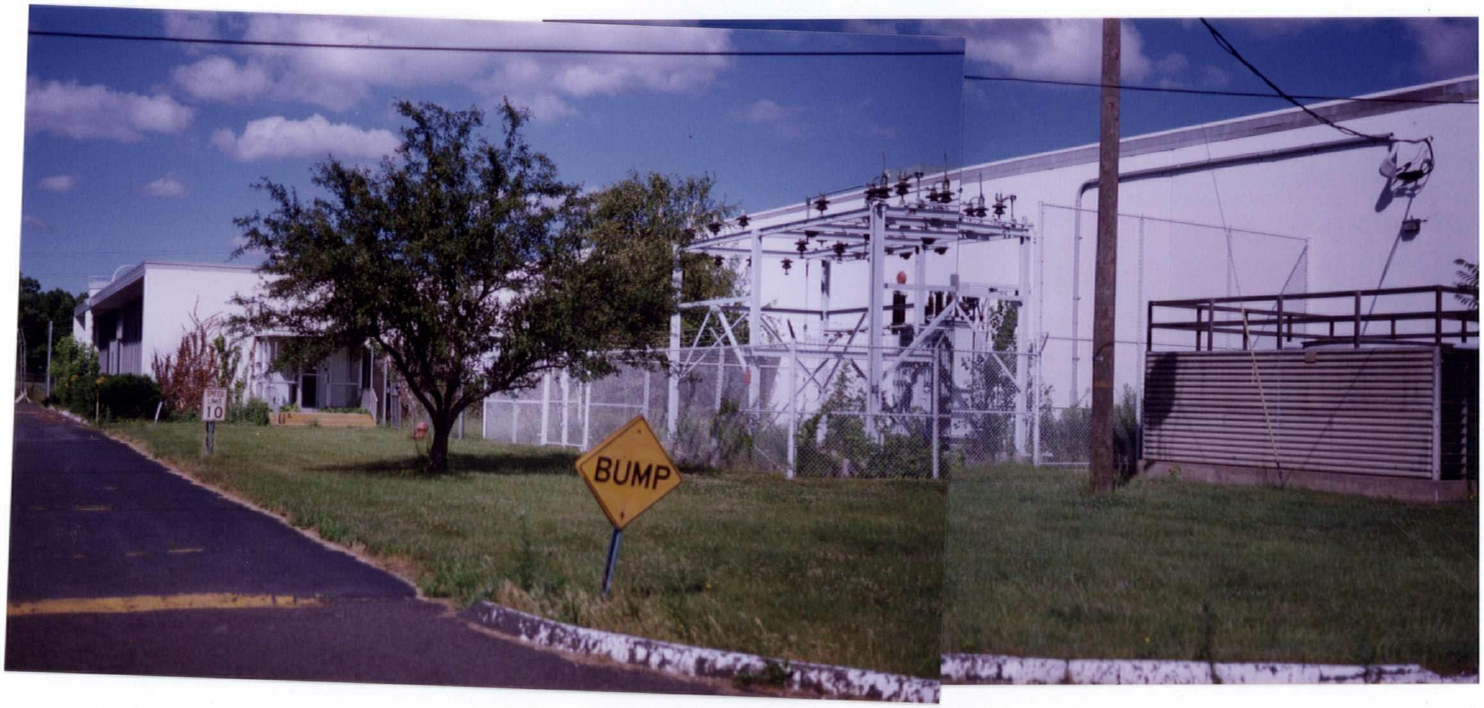
NUS CORPORATION

MONSANTO CORPORATION, HAMILTON TOWNSHIP, NEW JERSEY



1P-4,5 June 5, 1991 0935

Panoramic view looking west at the transformer area and the southern end of the office building.

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MONSANTO CORPORATION, HAMILTON TOWNSHIP, NEW JERSEY

1P-6 June 5, 1991 0950
View looking east at monitoring well in parking lot, directly east of the main warehouse.

1P-7 June 5, 1991 1000
View looking north at excavated material. Monitoring well No. 4 in background.

NUS CORPORATION

MONSANTO CORPORATION, HAMILTON TOWNSHIP, NEW JERSEY

1P-8,9 June 5, 1991 1005

Panoramic view looking southwest at south eastern side of the main warehouse.

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MONSANTO CORPORATION, HAMILTON TOWNSHIP, NEW JERSEY

1P-10 June 5, 1991 1005
View looking west at north eastern side of the main warehouse.

1P-11 June 5, 1991 1010
View looking north of fenced in propane tanks.

MONSANTO CORPORATION, HAMILTON TOWNSHIP, NEW JERSEY

1P-12 June 5, 1991 1015
View looking east at propane fill pipe area.

1P-13 June 5, 1991 1020
View looking west at the northern end of the main warehouse.

1P-14 June 5, 1991 1025
View looking north at water tank.

1P-15 June 5, 1991 1030
View of monitoring well between rail tracks, directly west of the main warehouse.

ATTACHMENT 2

REFERENCES

1. U.S. EPA Superfund Program, Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS). List 8: Site/Event Listing, and List 4 Site Alias Location Listing, pp. 131 and 156, May 1, 1991 and April 1, 1991.

2. General Sciences Corporation, Graphical Exposure Modeling Systems (GEMS). Landover, Maryland 1986.

3. Telecon Note: Converstation between Vincent Calisti, Superintendant, Burlington City Water Department and Anthony Bonasera, NUS Corporation, Region 2 FIT, March 7, 1991.

4. Telecon Note: Conversation between Janice Bailey, Trenton Water Works Engineering and Anthony Bonasera, NUS Corporation, Region 2 FIT, March 1, 1991.

5. U.S. Department of Commerce Rainfall Frequency Atlas of the U.S. Technical paper No. 40, Washington, DC, 1983.

6. RHRS Annual Net Precipitation, January 29, 1988.

7. Flood Insurance Rate Map, Township of Hamilton, New Jersey, U.S. Department of Housing, Community panel number 340246 0010 B, June 15, 1982.

8. Letter from Maureen Krudner, Geologist, Ground Water Management Section, U.S. EPA to Rich Feinberg, NUS Corp. March 14, 1991.

9. Bureau of Geology and Topography, State of New Jersey, Geology of the Ground Water Resources of Mercer County, 1965.

10. United States Environmental Protection Agency (U.S. EPA), Region 2, Edison, N.J., Preliminary Assessment Report on Monsanto Corportion, Hamilton Twp., Mercer Co., New Jersey, November 5, 1984.

11. Freeze, R.A., Cherry, J.A., Groundwater, New Jersey, Prentice-Hall, 1979.

12. Letter from L. Sherrerd Steele, P.G., Senior Hydrogeologist/Project Manager, Roux Associates Inc., to Anthony Bonasera, NUS Corp. June 21, 1991.

13. Environ Corporation, Presentation of the Phase I Sampling Plan Results for the Former Polychrome Corporation Facility, September 1988.

14. Environ Corporation, Presentation of the Phase II Sampling Plan Results for the Former Polychrome Corporation Facility, March 1990.

15. Memorandum from Ed Stevenson, Manager, Industrial Investigations Unit to Lester Taube, Office of Economic Development Department of Labor and Industry, Re: Inactive Monsanto Facility, Undated.

16. Four-Mile Vicinity Map based on U.S. Department of the Interior, Geological Survey Topographic Maps, 7.5 minute series, "Trenton East, N.J.", 1957, revised 1980; "Allentown, N.J.", 1957, revised 1980.

REFERENCES(CONT'D)

17. Field Notebook No. 0788, Monsanto Corp., TDD No. 02-9005-07, On-Site Reconnaissance, NUS Corporation, Region 2 FIT, Edison, NJ, May 22, 1991.

18. United States Geological Survey, Well Inventory pp. 52-56, January, 1989.

19. Telecon Note: Conversation between Jo Hanson, Monsanto Company and Anthony Bonasera, NUS Corporation, Region 2 FIT, July 11, 1991.

20. Telecon Note: Conversation between Ata Bonna, Hamilton Twp. engineering Dept. and Anthony Bonasera, NUS Corporation, Region 2 FIT, July 12, 1991.

21. Project Note: To Monsanto Co., TDD No. 02-9005-07, from Anthony Bonasera, Subject: Calculations of population on groundwater in 4 mile radius, Hamilton Twp., New Jersey, July 22, 1991.

REFERENCE NO. 1

EPA ID NO.	SITE NAME / STREET / CITY / COUNTY CODE AND NAME	STATE ZIP / CONG DIST.	NFA. FLAG	OPRBLE UNIT	EVENT TYPE	ACTUAL START DATE	ACTUAL COMPL DATE	CURRENT EVENT LEAD
NJD001700830	MONSANTO CO			00	DS1		03/01/80	EPA (FUND)
	1500 PINE ST				PA1		06/01/80	EPA (FUND)
	CAMDEN	NJ 08103			PA2	05/01/89	07/06/89	STATE(FUND)
	007 CAMDEN				SI1	03/01/80	08/01/80	EPA (FUND)
NJD001700707	MONSANTO CO			00	DS1		12/01/79	FED. FAC.
	RT #130				PA1		12/01/79	EPA (FUND)
	LOGAN TWP	NJ 08014			SI1	01/01/91	03/28/91	STATE(FUND)
	015 GLOUCESTER							
NJD980210009	MONSANTO CO			00	DS1		04/10/84	STATE(FUND)
	584 RTE 130				PA1	09/01/84	09/01/84	STATE(FUND)
	HAMILTON TWP	NJ 08619						
	021 MERCER							
NJD980785653	MONTCLAIR/WEST ORANGE RADIUM SITE			00	RS1	02/02/90	09/05/90	EPA (FUND)
	N/A				IR1	12/06/83	12/31/90	EPA (FUND)
	MONTCLAIR/W. ORANGE	NJ 07044-7052			PA1		10/01/84	EPA (FUND)
	013 ESSEX				NP1		10/01/84	EPA (FUND)
					NF1		02/01/85	EPA (FUND)
					SI1	09/01/84	10/01/84	EPA (FUND)
					OH1	04/29/87		EPA (FUND)
				01	CR1	06/17/86		EPA (FUND)
					WP1	12/13/84	04/02/85	EPA (FUND)
					CO1	12/13/84	06/30/89	EPA (FUND)
					RO1		06/30/89	EPA (FUND)
					RD1	05/25/89		EPA (FUND)
					RD2	12/09/87	09/30/89	EPA (FUND)
					RA1	09/15/89		EPA (FUND)
					MA1	03/21/88		EPA (FUND)
					TA1	03/01/85	06/30/89	EPA (FUND)
					DA1	12/09/87		EPA (FUND)
					AS1		04/01/84	EPA (FUND)
					OH1	11/06/87		EPA (FUND)
				02	CO1	03/30/90		EPA (FUND)
				03	CO1	12/13/84	06/01/90	EPA (FUND)
					TS1	11/06/87		EPA (FUND)
					RO1		06/01/90	EPA (FUND)

REGION: 02

EPA ID	SITE/ALIAS NAME STREET CITY COUNTY NAME	STATE COUNTY	ZIP CODE	ALIAS SEQ. #	NAME SOURCE	FED FAC
NJD980769699	MONROE TWP MUNICIPAL WELL #4 & #5 WASHINGTON AVE MONROE TWP GLOUCESTER	NJ 015	68694		EPA	N
NJD001700830	MONSANTO CO 1500 PINE ST CAMDEN CAMDEN	NJ 007	08103		EPA	N
NJD001700707	MONSANTO CO RT #130 LOGAN TWP GLOUCESTER	NJ 015	08014		EPA	N
	MONSANTO LF			01		
	MONSANTO CO /DELAWARE RIVER PLANT RTE 130 (PO BOX 296) BRIDGEPORT	NJ	08014	02		
	MONSANTO CO GLOUCESTER	NJ		03		
NJD980210009	MONSANTO CO 584 RTE 130 HAMILTON TWP MERCER	NJ 021	08619		EPA	N
	POLYCHROME CORP 584 RTE 130 YARDVILLE PLANT	NJ	08619	01		
	POLYCHROME CORP 584 RTE 130	NJ	08619	02		
NJD980785653	MONTCLAIR/WEST ORANGE RADIUM SITE N/A MONTCLAIR/W. ORANGE ESSEX	NJ 013	07044-7052		EPA	N

REFERENCE NO. 2

GSC-TR8645

GRAPHICAL EXPOSURE MODELING SYSTEM

(GEMS)

USER'S GUIDE

VOLUME 2. MODELING

Prepared for:

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF PESTICIDES AND TOXIC SUBSTANCES
EXPOSURE EVALUATION DIVISION
Task No. 3-2
Contract No. 68023970
Project Officer: Russell Kinerson
Task Manager: Loren Hall

Prepared by:

GENERAL SCIENCES CORPORATION
8401 Corporate Drive
Landover, Maryland 20785

Submitted: December 1, 1986

GEMS> I

Monsanto Corporation
LATITUDE 40:11:19 LONGITUDE 74:39:22 1980 POPULATION

KM	0.00-.400	.400-.810	.810-1.60	1.60-3.20	3.20-4.80	4.80-6.40	SECTOR TOTALS
S 1	0	235	2604	14843	23877	24702	66261
RING TOTALS	0	235	2604	14843	23877	24702	66261

GEMS> I

Monsanto Corporation
LATITUDE 40:11:19 LONGITUDE 74:39:22 1980 HOUSING

KM	0.00-.400	.400-.810	.810-1.60	1.60-3.20	3.20-4.80	4.80-6.40	SECTOR TOTALS
S 1	0	67	789	5071	7815	9006	22748
RING TOTALS	0	67	789	5071	7815	9006	22748

REFERENCE NO. 3

NUS CORPORATION AND SUBSIDIARIES — **TELECON NOTE**

CONTROL NO:	DATE:	TIME:
02-9005-07	3/1/91	10:00 a.m.

DISTRIBUTION:

BETWEEN:	OF:	PHONE:
Janice Bailey	Trenton Water Works Engineering	(609) 989-3212

AND: Anthony Bonasera

DISCUSSION:

Janice Bailey informed me that Hamilton, from Kuser Rd to Rte 130 — South, not including Crosswicks, recieves its water entirely from surface water from the Delaware River. A centrally located treatment plant is the source of distribution. She also stated the Intake off the Delaware is located at the Trenton Water Works Plant at the Calvin St. Bridge & Rte 29.

ACTION ITEMS:

Anthony Bonasera 3/1/91

NUS 087 REVISED 0685

REFERENCE NO. 4

NUS CORPORATION AND SUBSIDIARIES — **TELECON NOTE**

CONTROL NO:	DATE:	TIME:
02-9005-07	3/7/91	2:30 pm

DISTRIBUTION:

BETWEEN:	OF:	PHONE:
Vincent Calisti	Superintendant Burlington City Water Dept.	(609) 386-0307

AND: Anthony Bonasera

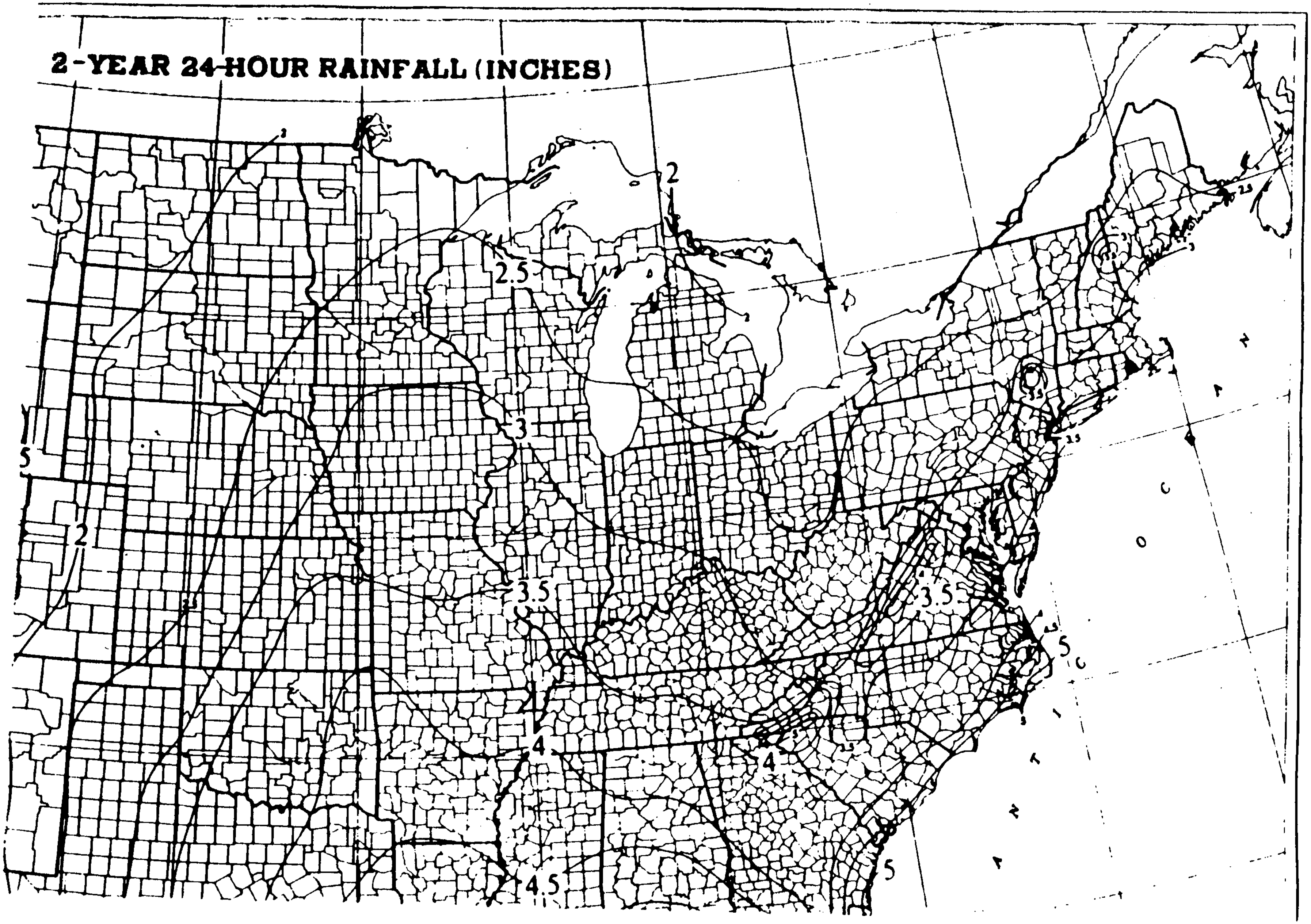
DISCUSSION:

Mr Calisti told me that Burlington has one surface water intake / Pumping station located on the Southern side of Burlington Island. He said the approximate recieving population is 10,546 people. He further told me that there are no other surface water intakes between Burlington and Trenton (water Company).

ACTION ITEMS:

Anthony Bonasera 3/7/91

REFERENCE NO. 5


2-YEAR 24-HOUR RAINFALL (INCHES)
2
2.5
3
3.5
4
4.5
5
2
5
3.5
4
5
O C E A N
A T L A N T I C

REFERENCE NO. 6

OBS	STATE	NAME		LATNUM	LONNUM	NETPREC
1761	26	ELKO WSO	R	40.50	115.47	3.9823
1762	26	WINNEMUCCA WSO	//R	40.54	117.48	2.5945
1763	26	WELLS		41.07	114.58	3.8866
1764	26	CONTACT		41.47	114.45	2.8738
1765	26	OWYHEE		41.57	116.06	5.9976
1766	27	NASHUA 2 NNW		42.47	71.29	23.7651
1767	27	PETERBORO 2 S		42.51	71.57	23.6732
1768	27	KEENE		42.55	72.17	19.8050
1769	27	MASSABESIC LAKE		42.59	71.24	19.8753
1770	27	SURRY MOUNTAIN DAM	R	43.00	72.19	18.5269
1771	27	DURHAM		43.08	70.56	23.9858
1772	27	CONCORD WSO	R	43.12	71.30	18.2330
1773	27	BLACKWATER DAM	R	43.19	71.43	22.5086
1774	27	LAKEPORT		43.33	71.28	21.8009
1775	27	LEBANON FAA AIRPORT		43.38	72.19	16.6971
1776	27	HANOVER		43.42	72.17	17.8320
1777	27	WOODSTOCK		43.59	71.41	24.1205
1778	27	PINKHAM NOTCH		44.16	71.15	37.6073
1779	27	MT. WASHINGTON WSO		44.16	71.18	76.0940
1780	27	BETHLEHEM		44.17	71.41	17.3621
1781	27	FIRST CONN LAKE		45.05	71.17	24.1798
1782	28	CAPE MAY 1 NW		38.57	74.56	17.9246
1783	28	BELLEPLAIN ST FOREST		39.15	74.52	19.8232
1784	28	MILLVILLE FAA AIRPORT		39.22	75.04	19.0414
1785	28	ATLANTIC CITY MARINA		39.23	74.26	17.0983
1786	28	ATLANTIC CITY WSO		39.27	74.34	19.0678
1787	28	SHILOH		39.28	75.18	16.6988
1788	28	HAMMONTON 2 NNE		39.39	74.48	19.6846
1789	28	GLASSBORO		39.42	75.07	19.9029
1790	28	INDIAN MILLS 2 W		39.48	74.47	20.4249
1791	28	PEMBERTON 3 E		39.58	74.38	20.0246
1792	28	MOORESTOWN		39.58	74.58	19.2450
1793	28	TRENTON WSO	R	40.13	74.46	17.6355
1794	28	FREEHOLD		40.16	74.15	21.6099
1795	28	HIGHTSTOWN 1 N		40.17	74.31	19.9454
1796	28	LONG BRANCH 2 S		40.19	74.01	22.6468
1797	28	LAMBERTVILLE		40.22	74.57	19.6500
1798	28	NEW BRUNSWICK		40.29	74.26	20.7743
1799	28	FLEMINGTON 1 NE		40.31	74.51	22.6137
1800	28	PLAINFIELD		40.36	74.24	23.1843
1801	28	SOMERVILLE 3 NW		40.36	74.38	20.7771
1802	28	NEWARK WSO	R	40.42	74.10	18.7257
1803	28	JERSEY CITY		40.44	74.03	20.3230
1804	28	CANOE BROOK		40.45	74.21	24.3936
1805	28	LONG VALLEY		40.47	74.47	26.5163
1806	28	ESSEX FELLS SERV BLDG		40.50	74.17	24.1529
1807	28	MORRIS PLAINS 1 W		40.50	74.30	25.4324
1808	28	BELVIDERE		40.50	75.05	21.1412
1809	28	LITTLE FALLS		40.53	74.14	24.5383
1810	28	BOONTON 1 SE		40.54	74.24	24.0122
1811	28	CHARLOTTEBURG		41.02	74.26	27.3932
1812	28	NEWTON		41.03	74.45	20.6676
1813	28	SUSSEX 1 SE		41.12	74.36	21.7773
1814	29	COLUMBUS		31.50	107.39	0.2019
1815	29	JAL		32.07	103.12	0.0000

REFERENCE NO. 7

NATIONAL FLOOD INSURANCE PROGRAM

FIRM

FLOOD INSURANCE RATE MAP

TOWNSHIP OF
HAMILTON,
NEW JERSEY
MERCER COUNTY

PANEL 10 OF 20
(SEE MAP INDEX FOR PANELS NOT PRINTED)

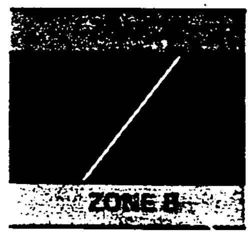
COMMUNITY-PANEL NUMBER
340246 0010 B

EFFECTIVE DATE:
JUNE 15, 1982

Federal Emergency Management Agency

KEY TO MAP

500-Year Flood Boundary
100-Year Flood Boundary
Zone Designations*
100-Year Flood Boundary
500-Year Flood Boundary

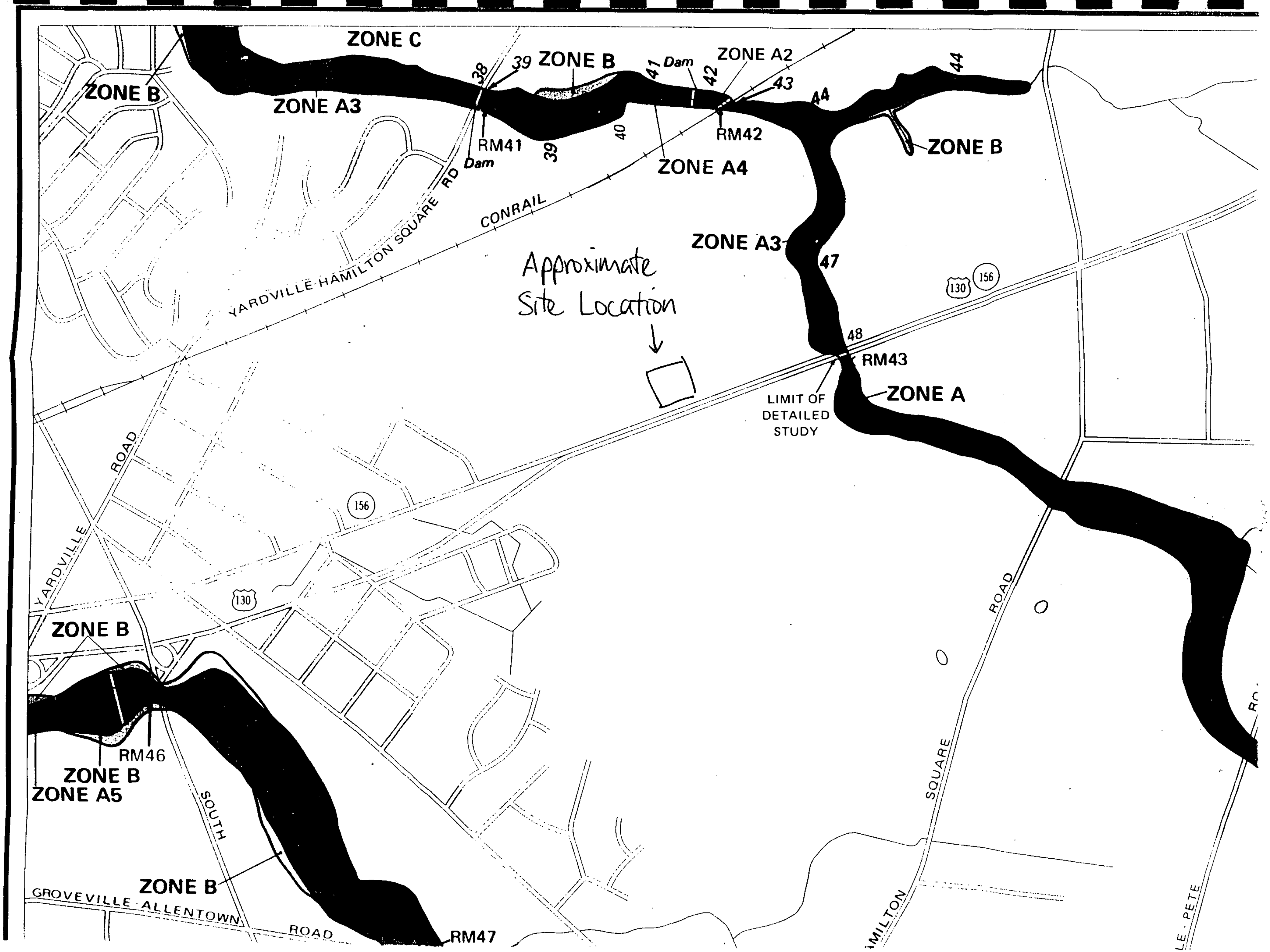


Base Flood Elevation Line With Elevation In Feet**	513
Base Flood Elevation in Feet Where Uniform Within Zone**	(EL 987)
Elevation Reference Mark	RM7×
Zone D Boundary	— — —
River Mile	•M1.5

**Referenced to the National Geodetic Vertical Datum of 1929

*EXPLANATION OF ZONE DESIGNATIONS

ZONE	EXPLANATION
A	Areas of 100-year flood; base flood elevations and flood hazard factors not determined.
A0	Areas of 100-year shallow flooding where depths are between one (1) and three (3) feet; average depths of inundation are shown, but no flood hazard factors are determined.
AH	Areas of 100-year shallow flooding where depths are between one (1) and three (3) feet; base flood elevations are shown, but no flood hazard factors are determined.
A1-A30	Areas of 100-year flood; base flood elevations and flood hazard factors determined.
A99	Areas of 100-year flood to be protected by flood protection system under construction; base flood elevations and flood hazard factors not determined.
B	Areas between limits of the 100-year flood and 500-year flood; or certain areas subject to 100-year flooding with average depths less than one (1) foot or where the contributing drainage area is less than one square mile; or areas protected by levees from the base flood. (Medium shading)
C	Areas of minimal flooding. (No shading)
D	Areas of undetermined, but possible, flood hazards.
V	Areas of 100-year coastal flood with velocity (wave action); base flood elevations and flood hazard factors not determined.
V1-V30	Areas of 100-year coastal flood with velocity (wave action); base flood elevations and flood hazard factors determined.



ZONE C
ZONE B
ZONE A3
39
38
41 Dam
42
ZONE A2
43
44
44
RM41
Dam
39
40
RM42
ZONE A4
ZONE B
CONRAIL
YARDVILLE-HAMILTON SQUARE RD
ZONE A3
47
Approximate
Site Location
130
156
48
RM43
ZONE A
LIMIT OF
DETAILED
STUDY
ROAD
156
YARDVILLE
130
ZONE B
RM46
ZONE B
ZONE A5
SOUTH
ROAD
SQUARE
ZONE B
GROVEVILLE ALLENTOWN
ROAD
RM47
HAMILTON

REFERENCE NO. 8

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION II

JACOB K. JAVITS FEDERAL BUILDING

NEW YORK, NEW YORK 10278

MAR 14 1991

Rich Feinberg
NUS Corporation
1090 King Georges Post Road
Suite 1103
Edison, NJ 08837

Dear Mr. Feinberg:

As discussed on March 12, 1991, the status of New Jersey's Wellhead Protection Plan is as follows:

New Jersey has not yet submitted a final Wellhead Protection Plan for EPA approval. The document is currently in draft form and is being circulated for public comment. EPA expects that a final plan will be submitted by this summer.

If you need further assistance, you may contact me at 212-264-4124.

Sincerely,

Maureen Krudner

Maureen Krudner, Geologist
Ground Water Management Section

REFERENCE NO. 9

State of New Jersey

Department of Conservation and Economic Development
ROBERT A. ROE, *Commissioner*

Division of Resource Development
KENNETH H. CREVELING, *Director*

GEOLOGY of the GROUND WATER RESOURCES of MERCER COUNTY

by

KEMBLE WIDMER,
State Geologist

BUREAU OF GEOLOGY AND TOPOGRAPHY
P. O. BOX 1889
TRENTON, NEW JERSEY 08625

— 1965 —

SUMMARY

Engineers, officials, realtors, planners, and citizens with an interest in ground water resources will find in this report summaries of reasonable expectations of depth and yield for wells drilled anywhere in Mercer County. Drillers' reports from over 1,000 wells have been analyzed and summarized by geological formation, by township, and with respect to local problems. Maximums, minimums, averages, and probabilities of depth and yield for domestic or industrial wells for any part of Mercer County can be determined from the data provided. Information and maps concerning watershed areas, industrial zones, and water company service areas are also provided.

All water supplies in Mercer County are derived from: (a) the Delaware River along the western border of the county; (b) the Delaware and Raritan Canal running southward along the Delaware River to Trenton and then northeastward following Assunpink Creek, Shabakunk Creek, Stony Brook, and the Millstone River until it leaves the county northeast of Princeton; (c) surface waters from farm ponds, impoundments, or from the minor streams of the county; or (d) from wells. Surface water supplies and their development or utilization are further complicated by laws which limit the movement of water from the Delaware River Basin, the southwestern two-thirds of the county, into the Raritan River Basin, the northeastern third of the county. At the present time a limited amount of water may be taken through the Delaware and Raritan Canal. There are both legal and physical limits as to the amount of water which can be taken from the canal and utilized in different parts of Mercer County.

Most of the population of Mercer County concentrated in the area around Trenton is supplied by the Trenton Water Company with water drawn from the Delaware River. Other urbanized areas are supplied by water companies depending upon wells. While most of the suburban expansion has so far occurred in areas which can be supplied by existing water companies or where individual wells are not too expensive and are usually adequate, in several townships, particularly in the northern part of the county, pressures have developed in recent years to permit construction of realty improvements whose water requirements exceed or will exceed the ground water supply obtainable within and near their boundaries.

Of the three major industrial zones in Mercer County, all of which cross the Delaware Basin-Raritan Basin Drainage Divide, the southern zone along U. S. Route 130 is supplied by large capacity wells completed in the Raritan formation; the central zone along U. S. Route 1 and the Pennsylvania Railroad mainline has limited ground water supplies but is close to the Delaware and Raritan Canal; and the northern zone, near U. S. Route 69 and the Reading Railroad, has neither surface water supplies nor the expectation of more than moderate supplies from wells.

In short, while most of Mercer County has adequate to moderate water supplies available for domestic and many industrial uses, southern and central Mercer County have the greatest future potential for the development of large supplies from either underground or surface water sources. This generalization, however, must be applied with caution. The areas for some specific uses such as irrigation wells, wells for high rise apartments, or industry with a large water requirement are limited in the county.

Ground water supplies are limited in areas underlain by Precambrian rocks, by argillite and by diabase. Unless surface water supplies or water piped in from outside the area is available, industrial development and housing developments on lots of less than two acres should be discouraged in areas underlain by argillite, by diabase, and perhaps by Precambrian rocks.

The area of Precambrian rocks extends northeastward from Trenton to Princeton Junction. Domestic wells are adequate ranging from 50 gpm to no water with most in the 5 - 9 gpm range. Industrial wells range from 175 gpm to 0 gpm and average about 35 gpm with only about one-third giving more than 50 gpm. Nearly all of the area underlain by Precambrian rocks is covered by Pleistocene sediments which provide well water in some areas.

There are several bands of argillite in northern Mercer County which contain very limited supplies of ground water. Over one-third of the domestic argillite wells give an inadequate 4 gpm or less. One argillite well in ten yields less than 2 gpm. A few industrial wells have been attempted, chiefly in the area between West Trenton and Pennington. The maximum yield for an industrial well was 90 gpm, while over half of the wells gave 20 gpm or less.

Diabase is found in the Rocky Hill sill in northern Mercer County and in several intrusive plugs in Hopewell Township. No industrial wells have been attempted in areas underlain by diabase. Domestic wells range from 100 gpm to nothing with only one well in ten giving water in excess of 10 gpm.

Adequate domestic wells and moderately large industrial wells can be developed in the areas of northern Mercer County underlain by the Stockton sandstone and Brunswick shale. The maximum yield for a domestic well (60 gpm) and the average yield (15 gpm) are the same for both formations. Only about 5% of the shale wells and only 3 out of 118 sandstone wells drilled for domestic water supply are inadequate with a yield of less than 5 gpm. Housing developments in areas underlain by shale and sandstone relying on individual wells and septic tanks will require a minimum lot size in excess of two-thirds of an acre if ground water resources are not to be depleted.

Industrial wells completed in the Brunswick shale have an average yield of 110 gpm and range downward from 470 gpm with more than half of the wells giving in excess of 50 gpm. Industrial wells in the Stockton sandstone average about 20 gpm more than the shale wells and range downward from 905 gpm. Well records suggest that industrial wells will be most successful if the plot is large enough and the location such that wells may be drilled on or near linear topographic features which reflect a geologic structure.

Wells in the Coastal Plain section of Mercer County are completed in either the Magothy-Raritan formation or in the thicker accumulations of the surficial Pleistocene deposits.

The lower Raritan contains too much clay or silt or is too thin to produce water until a stratigraphic thickness of about one hundred feet has been reached. South of this line (shown on Plate V) domestic wells can be completed in the Raritan formation anywhere in the county. The depth of domestic wells usually increases toward the south, but domestic wells can be completed in sand horizons at many different levels in both formations. Magothy-Raritan domestic wells average from 15 - 19 gpm with a maximum yield of 80 gpm.

The larger industrial wells completed in the Magothy-Raritan are usually found drawing from the lower part of the Raritan formation and are located near or along the line of Route 130. Industrial wells range from 1,500 gpm down to 35 gpm with an average and median yield of between 250 gpm and 300 gpm. An industrial well with a capacity of 500 gpm is a reasonable expectation for a carefully constructed well completed in the Raritan formation.

Pleistocene sediments form a surficial cover over a large part of Mercer County. Along the Valley of the Assunpink and Shabakunk from Trenton towards Bakers Basin and Clarksville Pleistocene sediments may be an important source of water because of the poor ground water yields from the underlying crystalline rocks. Thick Pleistocene accumulations in eastern Mercer County from Princeton Junction and Dutch Neck toward Hightstown are a second area of thick water-bearing Pleistocene sediments. Pleistocene wells are seldom more than 100 feet deep because of the limited thickness of the deposits. Domestic wells have an average and median yield of around 15 gpm. The largest Pleistocene industrial well gives 340 gpm and the successful wells average from 50 gpm to 100 gpm. In a number of predictable locations, however, the Pleistocene sediments are dry and repeated attempts to secure water from them have been unsuccessful.

The yields and depths of wells drawing from each formation in the county is given at the end of this section. Yield figures indicate the range, and expected averages. Depth figures must be used with caution because the Raritan is generally deeper in the southern part of the county, the depth of Pleistocene wells is limited by the thickness of the formation, and rock wells are frequently deeper than actually required.

The tabulation of depth figures for rock wells for the county as a whole by geologic formation provides an indication of the maximum range of depths which may be expected in any given formation. The well may or may not have secured most of its water at or near the maximum depth; many records do not indicate the depth at which most of the water was secured. In the case of deep domestic wells, a long hard look at the local relationships should be taken if a satisfactory domestic supply has not been secured after reaching a depth of 300 to 350 feet. In the case of industrial wells, those drilled in excess of 400 feet, while sometimes successful in securing large quantities of water, do not usually give quantities which equal the average of those wells drilled between 200 feet and 400 feet deep.

In the rock formations of the Stockton, Brunswick, Lockatong, Diabase, and Precambrian, most of the deepest wells were probably drilled to the depths indicated in an attempt to get additional water. There may have been no alternative but to go deeper because of the lot size or other local conditions.

In the case of the depth of wells in the sand formations, the Pleistocene and Raritan, it should be recognized that the Pleistocene most frequently is less than 70 feet thick. In several large areas, it is less than 30 feet thick and only occasionally does it exceed a thickness of 100 feet. On the other hand, the Raritan formation is usually found beneath a Pleistocene cover ranging from 10 feet to 150 feet in depth. In southern Mercer County wells must also penetrate as much as 150 feet of younger overlying Cretaceous sediments before reaching the top of the Raritan.

The Raritan has a general dip, or seaward slope, to the southeast which increases about 80 feet for each mile traveled towards the ocean. Wells completed in the Raritan may have been drilled to a deeper horizon in order to secure a better quality of water. It should also be noted that the hard "granite type" rocks of the basement which underlie the Raritan formation have a relief of probably 200 feet and that there are several areas, the most notable around Edinburg, where the Raritan may be very thin or missing. If the depth or thickness of the Raritan is computed on the basis of the average depth of the formation in some of these areas of "high" or "low" basement it would be quite erroneous.

MERCER COUNTY

DOMESTIC WELLS

Formation	*No. of Wells*	*YIELD IN GALLONS PER MINUTE* *Maximum*	*Minimum*	*Average*
Pre-Triassic	26	50	0	10
Stockton	148	60	1	20
Argillite	208	135	1/5	9
Brunswick	186	60	1/2	15
Diabase	100	100	0	9
Raritan	120	80	3	19
Pleistocene	20	80	3	13

INDUSTRIAL WELLS

Formation	*No. of Wells*	*YIELD IN GALLONS PER MINUTE* *Maximum*	*Minimum*	*Average*
Pre-Triassic	41	266	0	41
Stockton	80	905	18	147
Argillite	16	90	1/2	32
Brunswick	29	470	8	110
Diabase	none	..	..	..
Raritan	69	1500	35	327
Pleistocene	27	340	2	112

MERCER COUNTY

DOMESTIC WELLS

Formation	*No. of Wells*	*DEPTH IN FEET BELOW SURFACE* *Maximum*	*Minimum*	*Practical Depth Limit*	*Formation Thickness*
Pre-Triassic	26	350	52	400	Unknown
Stockton	149	670	22	400	3300
Argillite	209	798	40	400	2900
Brunswick	156	397	45	400	4850
Diabase	72	404	42	400	Unknown
Raritan	120	456	55	500 (?)	300
	(Increases in a southerly direction)				
Pleistocene	20	125	20	150	150

INDUSTRIAL WELLS

Formation	*No. of Wells*	*DEPTH IN FEET BELOW SURFACE* *Maximum*	*Minimum*	*Practical Depth Limit*	*Formation Thickness*
Pre-Triassic	41	900	50	500	Unknown
Stockton	80	603	40	500	3300
Argillite	16	436	85	500	2900
Brunswick	28	800	150	500	4850
Diabase	none	..	..	500	Unknown
Raritan	69	537	67	500 (?)	300
	(Increases in a southerly direction)				
Pleistocene	28	135	25	150	150

NOTE: Wells through Raritan enter Precambrian.
Wells through Pleistocene enter Raritan or Precambrian.

GEOLOGY OF THE GROUND WATER RESOURCES OF MERCER COUNTY

INTRODUCTION

For many years the Bureau of Geology and Topography of the Department of Conservation and Economic Development or, as it is more widely known, the New Jersey Geological Survey, has been called upon by well drillers, private citizens, engineers, realtors, industrial developers, planners, officials of other agencies of the State Government, representatives of County Government, and by municipal officers for assistance in ground water problems and particularly in determining the reasonable expectations of depth and yield for water wells at specific locations in the State. In each case, records of nearby wells were consulted to determine the maximum, the minimum, the average, and the probabilities of both depth and yield of the proposed well. These well records—assembled over the last seventy years by the State Geologist's office—contributed by cooperating drillers, and secured since 1947 through the operation of the well drilling law—present a tremendous mass of raw data of varying reliability. Interpreted by the more experienced and better-trained geologists of the State Survey, the predictions have usually been very close to the actual depth and yield of the finished well.

In June of 1956, the Mercer County Industrial Commission asked the New Jersey Geological Survey to prepare a report on the ground water conditions within the County. The New Jersey Geological Survey agreed to undertake this compilation and interpretation of the records in its files with the understanding that it would be done as staff availability and the usual geologic activities permitted. From time to time since 1957 summaries for some of the individual townships have been presented to the Commission; however, it has been impossible to present the county picture until detailed studies of well records in all of the townships had been completed in 1962.

In 1956 and 1957, senior students in geology were used to compile and check the data. Although they did an excellent job, they did not have the necessary experience and judgment to evaluate many of the records. Starting in 1958, therefore, geologists on the New Jersey Geological Survey staff reexamined, recompiled, and reevaluated the records. By 1960 sufficient records had been compiled to indicate that field check of the geology of many specific areas were necessary in order to insure accuracy in the interpretation of the well records.

It is believed that this report, based on over 1,000 wells selected from the well records in the New Jersey Geological Survey files, if properly used, gives a reasonably accurate picture of the ground water conditions within the county, within its municipalities, and within the various geologic formations which underlie the county.

As the study progressed, it became obvious from discussions with municipal officials, realty developers, planning boards and members of the industrial commission that the greatest value of the report would only be secured if the variations in ground water availability could be studied against the political and economic background of the county as determined by such factors as zoning regulations, political boundaries, surface water availability, water company size and franchise areas, land use, and growth trends. Thus recommendations for the location of new wells for Lawrenceville had to consider not only the geology, but also the distance from the Trenton water mains, the location in the township of new major water users, and the probable future growth pattern of the township. On the other hand, the demonstrated inability of wells to provide adequate water supplies from some geologic formations and in some specific areas has already profoundly affected both the operation and location of industrial plants and the type and speed of residential development in Princeton, Hopewell, and West Windsor Township.

Purpose and Objective

It is the purpose of this study to indicate the reasonable expectation for ground water development for various purposes in the different parts of the county. By the examination of a sufficient number of well records for each geologic variation in subsurface conditions, the variables due to human optimism, pessimism and veracity as well as good and poor construction and procedure in the drilling of wells, should be equalized. By a careful evaluation of who is drilling, where they are drilling, how they drilled, and why they drilled, many of the extreme conditions can be recognized and more valid data developed for the prediction of future probabilities of depth and yield.

Anyone who believes in the sixth sense of "dowsers or water witches", in the presence of underground rivers, or in layer-cake-like Coastal Plain aquifers should not waste their time by further reading. Those who like precision, mathematical equations, and evaluation in technical terms will find the report a disappointment. The color, type, and geologic subdivision of the Coastal Plain formation for each foot of a well is of little importance if most of the wells drilled for household use in the area are completed at about the same depth and give an adequate supply. The computations for the transmissibility of the rock, its porosity, and the specific capacity per foot of aquifer are of dubious value when based on driller reports reading "red shell all the way" or "white sand five feet, black clay ten feet, etc." and reports of a drawdown test made with a bailer for an unspecified time. However, if the reports of a number of different drillers for wells in the same geologic formation within an area of a few square miles are compared, a pattern can be determined and will provide useful information for future prediction and planning about the ground water resources of the surrounding area.

In the preparation of this report records have not only been examined for their accuracy and adequacy, but they have also been measured against the criteria of "will the record provide useful information which will help develop a pattern." It is believed that this report shows that a more valid overall prediction can be made by examining a large number of partially wrong or partially completed records than by predicting from a few records whose completeness and accuracy have been established. The variations in geologic and hydrologic conditions for any individual well are still such that in the final analysis all that can be predicted before the well is actually drilled and tested is the trend and range of what may be expected.

Location

Mercer County is the most westerly of the three counties which extend across the narrow "waist" of New Jersey from Sandy Hook to the Delaware. Trenton, the county seat and state capitol at the center of the western border of the county, is found at longitude 74° 46′ West and latitude 40° 14′ North. The area and 1960 population figures for the several municipal subdivisions are given in the appendix. Thirty miles from Philadelphia and fifty miles from New York City, Mercer County is crossed by the mainline of the Pennsylvania and Reading Railroads, U. S. Routes #1, #130, #69 and #206 and the New Jersey Turnpike.

The Delaware River forms the western border of the county; and the Millstone River, which drains into Raritan Bay, forms the eastern boundary of the county. Hunterdon and Somerset Counties are to the north; Burlington and Monmouth Counties are to the south.

Mercer and Middlesex Counties are the only two counties in the state which lie partially in the Piedmont Physiographic Province underlain by the Triassic rocks of the Newark series and the Coastal Plain Physiographic Province underlain by Cretaceous sands, gravels, and clays. Mercer County, however, is unique among the New Jersey counties because of the long, narrow wedge of pre-Triassic crystalline rocks extending northeastward from their outcroppings in the Delaware River and in Trenton to the vicinity of Princeton Junction and because of the thick deposits of Pleistocene gravels which, in many places, overlie the crystalline pre-Triassic rocks in the valley of lower Stony Brook, the lower Assunpink and southward from these two streams.

Rainfall, Runoff and Climate

The average annual rainfall is about 42″ in the Trenton area, about 43″ to 44″ in the southern part of the county, and from 44″ to 45″ in the northern (Hopewell Township) hilly area. During a typical dry year (T.A.M.S. uses 1930) the rainfall varies from 33″ in the Trenton-Princeton area to 36″ in the northwest and 37″ in the southeastern section. Summer rainfall may be thirty to thirty-five percent more than in other seasons unless there is an extreme drought. In a typical wet year (T.A.M.S. uses 1952) rainfall varies from 55″ in the border areas of the county to 61″ at Trenton.

In Mercer County there are stream gauging stations on the Delaware and Assunpink at Trenton and on the Millstone near Kingston. Average surface runoff in Mercer County is from 18″-19″ or 850,000 to 900,000 gallons per day per square mile. During a dry year surface runoff is about 11″ over most of the county, but is 12″ to 13″ in the basin of the Millstone River. During a wet year (T.A.M.S. used 1951-1952) runoff in the Piedmont Province area of Mercer County is 29″-30″ in contrast to the 24″-27″ in the area of the Coastal Plain Province. There is an annual difference of about 25″ between precipitation and runoff in Mercer County.

Precipitation is about evenly divided for the year with from three to five inches per month. About every eleven years there is a 15%-20% reduction in the amount of precipitation. This is usually felt as a drought of lasting at least thirty days which occurs during the growing season. A longer weather cycle may result in an occasional dry year with only 50% of normal precipitation.

Mercer County has moderately cold winters with average temperatures from 30° to 39° F. and extremes from −10° to 72° F. Very low temperatures do not last for more than a few days. Snow may stay on the ground for several weeks and reach a depth of 12 inches. The ground usually freezes to a depth of a foot or more. Summer temperatures range from 41° F. to 105° F. with an average of 72° F. The average growing season is about 195 days from April 16 to October 28. Killing frosts have occurred as late as May 12th and as early as October 11th.

Previous Work

A geologic map of Mercer County and adjacent areas was prepared in 1909 by Bascom, Darton and Kummel and published as the Trenton Folio. The Triassic deposits in Mercer County were described in considerable detail in 1896 and 1897 by Kummel. Salisbury in 1902 in Glacial Geology and in 1917 with Knapp in Quaternary formations described the details of various Pleistocene deposits in Mercer County. The geology of Mercer County including the glacial deposits is shown on the State Geologic Map prepared by Kummel and Lewis in 1910-1912 and revised by M. E. Johnson in 1950. Recent work by McLaughlin and Van Houten has greatly enlarged knowledge about the nature and occurrence of argillite.

Ground water conditions in Mercer County were touched on in 1955 in the T.A.M.S. Report and by Barksdale, et al., in Special Report #13 on the Tri-State Region of the Lower Delaware. Although both reports provided valuable information about ground water conditions and geology of the county, they are too general in scope to be useful in solving the detailed ground water problem.

Detailed information has been available either in the Permanent Notes maintained by the New Jersey Geological Survey since the 1880's or from the well record files. A file of well records from cooperating drillers was maintained until 1947 when the supply of information was greatly increased through well record forms received as a result of the operation of the drilling law. Also in the files of the New Jersey survey are copies of several Princeton University student theses on various subjects related to geology and ground water. A detailed citation of references of the published works mentioned above is given in the bibliography at the end of this report.

Compilation of Well Data

The City of Trenton and the eight townships in Mercer County were chosen as the units for the compilation of well records. The smaller municipal subdivisions such as Princeton Borough, Pennington, Hightstown, or Crosswicks were considered as part of the adjacent or surrounding township. As each well record was examined, it was given the next consecutive number on the compilation sheet for the township being studied. The well location was plotted on the well location map and the number used on the compilation sheet placed next to the location dot. *For each township,* therefore, *there is an indepedent series of numbers.*

It should be recognized at the outset that the figures given are not precise but rather should be used as a guide to reasonable expectations. Summations have been made from well drillers' reports whose locations and figures have varying degrees of accuracy. The sampling has been more or less at random rather than by any fixed statistical method. There are still many geologic factors that are not yet understood which can and do affect the individual wells. Every effort has been made to eliminate errors, to achieve a truly representative sampling, and to give due consideration to the geologic and other factors which affect the compilation and interpretation. Time and time again as compilations were made, both by area and by formation, the results indicated the profound effect which the geologic structure, the changing character of the formation, and the regional geologic history of the area has had upon the ground water availability. Small, almost unnoticed changes in geologic conditions may radically change the ground water conditions in the same geologic formation in a very short distance. The Raritan Formation in its lower part, the area underlain by the pre-Triassic rocks near Edinburg, and the structure and variations in the lithology of the Triassic in western Hopewell Township are excellent examples of the effect of seemingly unimportant or of unpredictable geologic changes within a small area upon the relative success of wells. Each of these geologic factors will be discussed in detail under the appropriate headings.

Within each township compilation, wells were considered as belonging to either a domestic or an industrial group. Wells for public water supply, for industrial use, or for irrigation are *classed as industrial wells.* The larger proportion of wells drilled in the county were for the use of individual households and were, therefore, tabulated as *domestic wells.* In the domestic group also were included wells for stores, churches, banks, filling stations, business offices, and even small industrial plants or other types of use where less than twenty gallons per minute were desired or where the permit or log indicated no special effort was made to get a large supply by increasing the diameter of the well or by drilling deeper than the usual domestic wells in the area.

In general, the industrial well summaries are probably more reliable than the domestic well summaries because wells requiring a large yield are more apt to be under the close supervision of the more reliable and more experienced drillers. The well data and well log for an industrial well are usually more complete because of development and pump test procedures from which more reliable data can be secured.

Upon completion of the township compilations and the well location map, the data were reexamined to provide summaries of depth and yield for wells drawing from each different geologic formation within the township. Summaries were then prepared for both depth and yield for each formation to show both the county-wide picture and a comparative picture for wells drawing water from the same geologic unit within the different townships. Special situations were noted and are discussed under the appropriate township.

Because of a popular concept that the deeper you drill the more water you will get, it must be emphasized again and again that *there is no relationship between the depth and the yield of any of the wells.* In the tabulation, the maximum and minimum depth and yield figures are almost never derived from the same well. Although there are some relationships as to the yield which may be expected in various areas and within various formations which are governed by depth, in general, any effort to derive a statistical or mathematical formula to show a specific depth and yield relationship is about as valid, when applied to a specific well, as a similar system applied to picking the winner of a horse race. The tabulations which follow should not be used to compare depth and yield except to say that a well of average depth will probably give an average yield, or that the range of either factor will be within the range given, or that the large yield of industrial wells is more likely to be secured at a greater depth than is required for a domestic well. It must be emphasized again that there is *no direct mathematical relationship between the depth of a well and its yield.*

The final stage in the compilation of data consisted of cross checking the summaries to be assured of their consistency and then examining the extremes and the averages to determine whether or not there was some unusual condition which would lead to unrealistic averages in the summaries. Some were found, and they are discussed either where these inconsistencies occur or in special sections when such a need arises.

Reliability of Data

Before considering the summaries of data for township areas or for the geologic formations, it would seem advisable to present some of the more significant factors which influence the presentation of information in the well report and thereby cause variation in the reliability of the data upon which the conclusions and estimates of the ground water conditions in Mercer County are based.

Throughout the selection of records and the compilation of the summaries, an effort has been made to eliminate inaccuracies by recognizing the difficulties and applying a *"philosophy of correction"* with respect to the report itself, the driller submitting the report, the time of submission, the use, the depth, the yield, the location, and the area around the well.

The *well report* form itself is designed to secure, with a minimum of effort on the part of the driller filling it out, the salient features of a well drilled either in rock or in sand. Some information requested may not be known when submitted, and some may be omitted or even erroneously given. Previous to 1947, a very similar form was used by the State Survey geologists. Regrettable as it may be, the forms are not always completed and may, in some cases, be inaccurate. However, the information given, although not all that may be desired, may be the best available and under such a circumstance must therefore be used.

The driller submitting the report cannot be forced by the drilling law to submit an accurate report. Most do; some will sometimes; some will on some items; and some few will not under any conditions. Thus one driller, who fortunately does not usually work in Mercer County, always has wells 120 feet deep giving seven gallons per minute from red shale. Fortunately his practice is restricted to wells for single dwellings in a red shale area. Thus the completed well report forms must be evaluated against the knowledge which the State Survey personnel have of the driller, the area, and the availability of better information. Need it be said that the reports of the driller cited above are filed without being used? However, such situations must be recognized, and such well reports excluded from statistical summaries. It should also be noted that bad news travels fast, and the State Geological Survey staff is usually one of the first to hear of unsatisfactory wells or of poor driller performance. At the other extreme of the tabulations the drillers themselves are usually quick to inform us about the exceptional or unusual wells.

The time of submission of the report is also a factor because reports submitted immediately after the drilling of a problem well will have more details and give a more accurate picture than a report written up several months after drilling along with reports on a number of other completed wells. Even more important than the time at which the well record is written is the age of the records themselves. Because drilling techniques and methods have changed over the years, older well records may present quite a different set of conditions as to depth, yield, and well construction than would be presented by a well drilled with a modern rotary, or developed by brushing and surging, or by gravel packing or some other relatively new drilling technique. For example, the use of, and the experience of a driller with, the large rotary drill rigs in the rock wells of Mercer County during the last few years could profoundly affect depth and yield figures if too many records were used in a summary. A reliable experience factor is lacking at this time, but the records received so far suggest that many wells drilled by rotary rigs in some rock types average deeper than those drilled by the cable tool rigs and, more often than not, will give less water *unless careful development procedures are followed.* The percussion-rotary rig using air, on the other hand, may prove better than the cable tool rig in many types of very hard rock.

The use of the well must also be considered because, as indicated earlier, well records for industrial, public supply, and irrigation wells are generally more reliable in the evaluation of the ground water available in a given geologic formation than are the reports on domestic wells. The greater cost of such wells usually results in their being drilled by the more experienced and better equipped drillers. Their construction is usually quite closely supervised and the pump tests and well development procedures are of much greater duration and more precise in measurement. Since such wells may call for the maximum amount of water than can be secured, they usually provide a better test of the ground water characteristics of the formation than do the small household wells where the desired small quantity of water is usually easily secured. If this is the case, the type duration and completeness of the pump test become very significant since they often will indicate whether the well can yield much or little more water than was required at the time of construction. It should be remembered, however, that in some areas of Mercer County where diabase, argillite, or Precambrian crystallines are the underlying rocks, an adequate domestic household water supply may require a well which in diameter, depth, and cost may approach the characteristics of a small industrial well. Thus the use of the well is an important factor in evaluating the ground water characteristics of a formation or an area, but the evaluation must always be made with due allowance for the overlap of depth and yield figures between domestic and industrial wells.

The depth of the well must always be carefully considered since the well may have been drilled much deeper than necessary or, in rare instances, prematurely abandoned before the desired supply could reasonably be expected. The topographic position of the well influences the depth since, all other things being equal, a well on a hilltop is usually deeper than one in a valley. Rock wells, because the water is secured from fractures which become less abundant and less open with depth, have rather definite limits as to the depth beyond which the probabilities of securing water decrease and finally cease. A few wells drawing water from Pleistocene gravels are limited in depth by the thickness of the formation. The sand wells of the Coastal Plain formations of southern Mercer County and South Jersey, on the other hand, must go deep enough to penetrate the water-bearing beds or aquifers which have a slope or dip to the southeast toward the ocean. Extremely deep rock wells should be checked against all known facts to determine, if possible, where the water was actually secured and whether or not they were drilled deeper in an effort to get more water than was found nearer the surface. Sand wells should be checked in a similar manner, but a good thick water-bearing sand is not usually ignored unless the quality of the water is poor or there is reason to believe there is a better sand at a greater depth. The ultimate depth of a sand well is the depth of the crystalline basement rocks or the economic limits imposed by possible alternate aquifers nearer the surface.

The yield figures for industrial wells are probably the most reliable. Industrial wells are generally closely supervised and usually provide for the installation of a pump and a pump test of several hours duration to indicate how much water the well will actually give. Under ideal conditions, the well should be pumped down and stabilized at the pumping level for a period of from 24 to 48 hours after the water level has ceased to drop. In the case of household wells, very few are tested with pumping equipment. Most tests are of short duration and by rather crude means. The reported yields of domestic wells depend a great deal on the driller's experience.

In the case of domestic wells, therefore, the Bureau of Geology finds the following relationships generally useful in judging whether or not a well should be considered poor, good, or exceptional. In general, if a yield is reported as less than five gallons per minute, we assume that the driller is probably rendering a correct report because he wishes it on the record that this was not a particularly good well in order to cover himself if the well goes dry at some future date. Where the yield is reported between five and twenty gallons per minute, we consider the well satisfactory for household use and assume that the test and the driller's experience indicate that the well is satisfactory as a domestic supply, but that the well test is, or may be, unreliable and the actual yield may be seven to ten gallons per minute for a well reported as yielding five, or perhaps the yield is only five gallons per minute even though the well is reported capable of yielding fifteen. The driller knows that the probabilities are that no one is going to check up on his figures with precise measurements. He knows the well will be satisfactory for the purpose and, therefore, puts down a figure which is only more or less accurate. In actual fact, wells reported as yielding fifteen or twenty gallons per minute have, in several instances when tested with a pump at a later date, given as little as seven or, in other cases, as high as sixty gallons per minute. Where the yield is reported for a domestic well in excess of twenty gallons per minute, it is assumed that the well is exceptionally good. Depending upon the amount of the test information given and the method of testing, there may be some indication that it is very much better than the yield reported or that the well is somewhere near the reported figure. For those wells which are reported as giving a great deal more water than twenty gallons per minute, it should be assumed that the industrial well averages, maximums, and minimums would apply.

The location of a well given on the permit is usually fairly good, but once in a great while errors in location of a mile or more from the actual location are found in the records. In general, most well drillers can read the topographic maps accurately enough so that the well location given is probably within one-quarter mile of the actual location. However, some drillers are notoriously poor at reading topographic maps and sometimes even the best efforts are confused by a location on one of two parallel local roads. Where the well location as given in the record is obviously wrong, for one reason or another, every effort has been made to establish the correct location or the well hasn't been used in the tabulation. Field checks of the locations given by the drillers have been made in many, but not all, cases. It is believed that a slightly erroneous location will have very little effect upon the averages as long as the well appears in the correct general area and in the proper geologic setting with respect to the formation from which it is drawing water.

The area around the well is the final variable which may cause an error when using the well records. Careful consideration must be given to the immediate area around any potential well site. There may be very few records because heretofore the area has been one of farms with large acreage. Under these conditions, there are usually very few wells, and most of these have been drilled for domesic use. A tabulation of a number of small domestic wells in a given area would not give the answer as to whether or not a satisfactory industrial supply could be obtained. With no industrial well records available, it would be necessary to consider not only other areas in the county underlain by the same rock type, but also other areas where an attempt has been made to bring in large industrial wells. Naturally, the nearest possible area should be selected, and also the area should be along the strike of the formation so that the geologic conditions in the area from which the information is being secured will be, as nearly as possible, the same as the area for the potential well site. As a last resort, the county-wide figures for the proper formation may be used to arrive at an estimate of reasonable expectations of depth and yield.

Using the Report

Many regional ground water reports give the maximum and minimum yield of each geologic formation. The sample may be eight or ten wells or even several hundred. Usually mathematical values, also with extreme ranges, such as coefficient of storage, transmissibility, or specific capacity are also quoted. In many instances there is undoubted merit in such values and they do provide a standard criteria. However, when geologic conditions make it impossible to evaluate the pump test or when such statements as "The effect of the withdrawal is generally not transmitted any great distance from the well, probably no more than a few hundred feet in most localities. . . .," or ". . . . coefficients of transmissibility and storage determined by the analysis of field pumping tests must be considered in the light of local conditions and may not be compared with coefficients from other tests. In some cases the coefficients may be meaningless because they represent combined effects of withdrawals from aquifers of different types" (Barksdale 1958) there would seem to be something missing in the application of the report to local problem. The evaluation of a rock well 160 feet deep using a value for the thickness of the "aquifer" of 160 feet seems slightly ridiculous when the driller has gotten no water at 150 feet and then brings in a well giving 60 gpm.

This report is an effort to offset these deficiencies in a regional analysis by examining a large sample in many different areas and grouping the samples in such a way that an analysis can be made of equivalent past experience. To this end the entire report has been divided into tables and discussion of the domestic and industrial well groups. The costs, methods, desired yields, and practical depths are different in each group although the extreme values of depth and yield may be nearly the same in any formation.

After making the primary division as to type of well which best represents the problem and consulting Plate I or V for the geology, attention should be given to the spread of values as compared to the average yield for the geologic formation in which the well is to be constructed. The accompanying table, showing the four highest well yields for each formation in Mercer County, supplies the second most important factor in developing a reasonable expectation of yield. The county summaries of yield and depth at the end of the summary section in this report indicate whether the geologic formation at the proposed well site can meet the desired needs. If a well still seems to be in order, the section on the appropriate geologic formation may next be consulted to determine possible local limitations or alternatives.

If the county and the geologic formation values are favorable or indicate a reasonable possibility of success in securing the desired water, then the township summary may be consulted to get clues as to local geologic problems which may exist. This information may show that local conditions may limit the proposed well program. From nearby wells a set of rather detailed and specific data as to what is a reasonable expectation may be secured.

A typical inquiry may be used as an example. The question is asked as to whether or not 100 gpm can be secured for an industrial plant to go in just east of Trenton along the Pennsylvania Railroad. The industrial well classification is used. The "four highest vs. average" table and the county summary show that the well is possible in the pre-Triassic and probable in the Pleistocene, the two geologic units found in the area. The Hamilton Township summary would confirm this and indicate the nature of local problems. From the Hamilton Township and Trenton summaries a specific set of maximums, minimums, averages, and probabilities for the nearest Precambrian and Pleistocene wells could be prepared. Plate I gives the geology; Plates II and III indicate the general geologic relationships; and Plate V shows the areas of surface water supply and the general ground water evaluation of the area (in this case poor). Final details would be worked out with the driller who might be instructed to test the Pleistocene gravels. If they proved to be inadequate, he would then be instructed to drill to 300 feet into the Precambrian in an effort to get the needed water.

If the request had been one for 500 gpm, the problem would be quickly solved because summaries and discussions would indicate that it is extremely unlikely that any well would be successful in securing this amount of water. An alternate area, southern Mercer County, with a Raritan well or an alternate source of water, the Delaware and Raritan Canal, could be suggested.

Plates I, IV, and V were prepared from the State Atlas Sheets which may be used to secure the details of topography such as the presence of linear structures and the elevation of the well site as compared to the adjacent wells. A difference in elevation in excess of fifty feet should be compensated for in the depth estimates.

A discussion of the hydrologic cycle as it applies to Mercer County is included in the appendices.

Four Highest Yields and Average* Yield in Gallons per Minute
of Industrial and Domestic Wells in Various
Rock Formations in Mercer County

Rock Formation	No. of Domestic Wells in Sample	Yield in Gallons per Minute														No. of Industrial Wells in Sample
		Domestic							Industrial							
		1st	2nd	3rd	4th	Aver.	Ratio 1st-4th**	Ratio 4th-Aver.**	1st	2nd	3rd	4th	Aver.	Ratio 1st-4th**	Ratio 4th-Aver.**	
Pre-Triassic (Precambrian and Hardyston)	26	50	30	20	20	10	2½/1	2/1	266	175	150	100	41	2½/1	2/1	41
Stockton Sandstone	148	60	60	60	50	20	1½/1	2½/1	905	700	602	600	147	1½/1	4/1	80
Argillite	208	135	55	35	30	9	4½/1	3½/1	90	50	50	50	32	1½/1	1½/1	16
Brunswick Shale	186	60	60	60	45	15	1½/1	3/1	470	460	412	201	110	2/1	2/1	29
Diabase	100	100	60	27	25	9	4/1	3/1	..	..	..	..	..	..	..	none
Raritan (Magothy-Raritan)	120	80	66	60	60	19	1½/1	3½/1	1500	1150	1125	1040	327	1½/1	3/1	69
Pleistocene	20	80	40	30	20	13	4/1	1½/1	340	240	228	200	112	1½/1	2/1	27

* Arithmetic Mean

** Nominators rounded to nearest one-half.

THE GEOLOGY OF MERCER COUNTY IN BRIEF

A ridge of pre-Triassic quartzites, gneisses, and schists, which crops out in the Delaware River forming the falls of Trenton, extends eastward at or very close to the surface as far as Princeton Junction. These crystalline rocks, which form the so-called "basement," underlie the northwesterly dipping sandstone, argillites and shales of the Triassic Newark Group of the Piedmont Physiographic Province of northern Mercer County and underlie the southeasterly dipping Cretaceous and Tertiary Continental Shelf sediments which form the Coastal Plain Physiographic Province of southern Mercer County.

Except for outcropping in the Delaware River, along the beds of some of the creeks, and at one or two other locations, the crystalline rocks are capped and masked by a veneer of Pleistocene sediments. Most of Trenton, much of northeastern Hamilton Township and a considerable part of West Windsor Township are underlain by these crystalline rocks. South of the main line of the Pennsylvania Railroad, the crystalline rocks are close enough to the surface in the vicinity of Quaker Gardens, Dutch Neck and Edinburg to effectively limit the amount of water obtained from industrial and irrigation wells. The pre-Triassic rocks range from gabbros to granites and pegmatites, from schists to gneisses and include a wide band of quartzite.

In that part of Mercer County which is within the Coastal Plain Province, only four of the Coastal Plain Formations are exposed. Nearly half of this part of Mercer County is underlain by the Magothy and Raritan Formations which are a series of alternating clays and sands. The sand beds and lenses in the Raritan Formation, particularly when they are well-sorted and free of interstitial clay and silt, are extremely important as aquifers. The sands of the Magothy Formation are frequently satisfactory for domestic household well supplies; but it is the coarser, thick, well-sorted sands of the Raritan Formation which provide water to most of the industrial wells along Route 130 and the Pennsylvania Railroad freight line from Bordentown to South Amboy. Southeastward of the above-mentioned railroad and highway, the Merchantville and Woodbury clays underlie most of the rest of the county.

Most of Mercer County in the Coastal Plain Physiographic Province lies between elevations of sixty and one hundred feet. Streams generally flow northwestward until they join the Delaware River or Assunpink Creek both of which turn and flow westward near Trenton, generally along the northern boundary of the Coastal Plain parallel to the strike of the formations. The relatively flat terrain and the sandy soil of the Coastal Plain Province has led to the rapid growth of housing developments in southern Mercer County (Hamilton, Washington, East and West Windsor Townships). Many areas underlain by clays close to the surface are very swampy and have remained wooded while the sandier soils have been cleared for farming.

Northern Mercer County in the Piedmont Physiographic Province is underlain by the Stockton sandstone and Brunswick shale which rise to an elevation of about one hundred sixty feet and are cut by streams which flow into the Delaware, the Shabakunk, or Stony Brook. The areas underlain by Lockatong argillite or diabase intrusives form the highest terrain in the county with flat-topped ridges reaching the general elevation of two hundred feet. The main argillite zone extends from Scudder's Falls on the Delaware River to and through Princeton Borough. The diabase intrusives of Pennington Mountain on the Delaware in the northern part of the county reach elevations of just over four hundred feet. The westward extension of the Palisades sill forms Mt. Lucas north of Princeton and Mt. Rose (Elevation 415′) south of Hopewell. The Sourland Mountains and the high ground, with a general elevation in excess of three hundred feet, in the northern part of the county in the vicinity of Harbourton, Woodsville and north of Hopewell are underlain by sandstone, argillite or diabase.

The geologic structure of Mercer County is rather simple, with a normal sequence of Triassic strata dipping northwestward, and Cretaceous and Tertiary clays, sands, and gravels dipping southeastward from the ridge of crystalline rocks extending from Trenton to Princeton. Faults have been mapped in the crystalline rocks. A major fault in the Triassic on the north side of Hopewell Borough causes repetition of the Triassic sequence in most of northern Mercer County. Minor faulting occurs near the west end and on the south sides of the diabase intrusives of Mt. Rose, Pennington Mountain, and Baldpate Mountain.

Sections A-A′ and B-B′ on Plate II show the stratigraphy and structure described above.

Pleistocene deposits ranging from thick sheets of wind-blown loess, in the Stony Brook watershed near Pennington, to the coarse yellow gravels of the Pennsauken formation of the southern half of Mercer County conceal the bedrock and Coastal Plain formations in much of the county. Many of these deposits act as a sponge for the storage of water, make the soil more permeable, at times more fertile, and in a few places are thick enough by themselves to be used as aquifers or worked for their gravel.

STRATIGRAPHIC COLUMN FOR MERCER COUNTY

Geologic time intervals are arbitrary divisions of unequal length. Each may be matched by one or more geologic formations. An era, the largest division of geologic time, is subdivided into smaller units called periods. Formations, which are mappable rock units, are usually assigned to periods or smaller subdivisions of geologic time, on the basis of distinctive fossils, if present, or distinctive lithology. In the columns below the number in parenthesis indicates the total millions of years before the present when each geologic period began. The rock type given after the formation name is the most common variety. Other types of rocks are also usually present within the formation.

Era	*Period*		*Thickness In County*	*Formation and Rock Type*
		Recent (1/10)	30′?	Soil and alluvium
Cenozoic	Quaternary	(1)		
		Pleistocene	150′	Glacial deposits
		Pliocene	..	
	Tertiary	(70)		Not present in county
		Paleocene	..	
				Higher Cretaceous formations not present in county.
	Cretaceous	(135)	30′	Marshalltown—clay (most exposures outside county)
	(Coastal Plain)		120′	Englishtown—sand
	(Hamilton, Washington, Windsors,		50′	Woodbury—clay
	Hightstown area)		60′	Merchantville—clay
Mesozoic			250–300′	Magothy-Raritan—sand and clay
	Jurassic	(180)	..	Not present in New Jersey
	Triassic	(225)		
			4850′	Brunswick—shale
	(Hopewell, Ewing, Lawrence, Prince-		2900′	Lockatong—argillite
	ton area). Igneous rock-intrusive		3300′	Stockton—sandstone
	diabase (Hopewell, Princeton)		1300′	Igneous-diabase
	Permian	(270)		Not present in state
	Pennsylvanian			" " " "
	Mississippian	(350)		" " " "
Paleozoic	Devonian	(400)		Not present in county
	Silurian	(440)		" " " "
	Ordovician	(500)		" " " "
	Cambrian (Trenton area)	(600)	Unknown	Hardyston—quartzite
	Precambrian (Began billions of years ago) (Trenton area)		Unknown	No named formations in county Gabbros; pegmatites; gneisses; schists.

PRECAMBRIAN (PRE-TRIASSIC) ROCKS

Pre-Triassic rocks are found exposed in the Delaware River opposite Trenton, within the bed of Assunpink Creek and elsewhere in excavations in the city, eastward in Lawrence Township, and formerly as far east as Princeton Junction. This group of rocks consists of the Cambrian Chickies or Hardyston quartzite, an alleged equivalent of the Wissahickon schists which may be either Precambrian or early Paleozoic (post-Hardyston) and a meta-gabbro and other igneous rocks such as pegmatite and granite gneiss, which are generally classed as Precambrian in age. The outcrops in Mercer County are too sparse to permit the correlation with certainty of these formations to the more extensive outcrop area and exposures west of the Delaware River. The quartzite has a rather striking continuous outcrop across the river on either side of the Calhoun Street Bridge to Morrisville.

In the 1909 Trenton Folio these rocks are shown as outcropping from beneath the Pleistocene formations as far east as Bakers Basin. On the 1950 State Geologic Map, an outcrop area is indicated just west of Princeton Junction. Well drilling operations in the past few years in the area between Princeton Junction, Edinburg and Trenton suggest that the crystalline rocks lie close to the surface below a thin cover of Pleistocene deposits and underlie a much more extensive area and are much nearer the surface than has heretofore been indicated.

Since all of these rocks are hard crystallines, yielding water only from fractures, the age and lithologic differences are not important for the present study. However, when these rocks are close to the surface, are not capped by Triassic sandstones or Raritan sands and are covered only by Raritan clays or thin Pleistocene deposits containing much silt, the area underlain by these pre-Triassic rocks becomes important in studies of the ground water potential of Mercer County. For convenience in this study, in maps, sections, and discussion, these crystalline rocks are hereafter referred to as Precambrian without regard as to whether they are actually Precambrian gneisses or meta-gabbros, Cambrian quartzites, or younger gneisses and schists.

Field reconnaissance was conducted by the New Jersey Geological Survey in Mercer County during May, 1960 as a preliminary step in the preparation of a geologic base map for the ground water report on the area. The existing geologic maps did not seem to agree with information from new exposures and well data that were not available when the geologic map was revised in 1950.

Prior to commencement of field work, considerable research was conducted on published data on the pre-Triassic rocks shown in the Trenton and Princeton Junction areas on the State Geologic Map. Outcrop localities given in the permanent notes were noted on the new U.S.G.S. 1:24000 quadrangle sheets.

Field checking was started in the Trenton area. Precambrian gneiss in a highly weathered state was found beneath a few feet of overburden in the excavation for a large building 1,500 feet southeast of U. S. Route #1 on that part of the highway between Texas Avenue and the Lawrence Drive-In Theatre. This area was formerly mapped as Triassic on the geologic map. The occurrence of Precambrian gneiss at this locality and as outcrops to the west necessitated moving the Triassic-Precambrian contact in a northwesterly direction nearly one-fourth of a mile.

Reconnaissance was continued in a zone about three miles wide from Trenton to Princeton Junction on both sides but chiefly southeast of U. S. Route #1. All roads in this area crossing the Cretaceous-Triassic contact as shown on the geologic map were traveled. All areas of potential outcrop or exposure were examined including road cuts, stream banks, and excavations for buildings and garbage burial. It soon became evident that the contact zone as mapped was based on inference rather than on outcrop. No identifiable outcrops of Cretaceous or Triassic deposits were found within one-fourth mile of either side of the contact zone as previously mapped. Intensive search disclosed only Pleistocene deposits at or near the surface. Clay was found in the area between the Delaware and Raritan Canal and Assunpink Creek just south of Bakersville. The white and gray clay, upon cursory examination, appeared to be Cretaceous, however, detailed examination and comparison of samples suggests that this clay is a Pleistocene deposit, consisting largely of reworked Raritan Formation and/or Precambrian saprolite materials.

Mention was made in the permanent geologic notes of several Precambrian outcrop areas which apparently were utilized in preparing the State Geologic Map. All of these localities were visited and field-checked for this report, and all apparently have been covered by sanitary land fill or other construction in recent years. One of these locations was on the north side of the railroad at a crossing near Duckpond Run, two miles southwest of Princeton Junction. This, apparently, was concealed by the fill for the construction of a highway overpass. The most famous locality, a few hundred yards southwest of the Princeton Junction Station, is now utilized by West Windsor Township as a dump, and the Precambrian outcropping is no longer visible. However, the yellow and white conglomerate, typical of the basal Triassic, is still visible north of the dump. A newly constructed farm pond, south of the railroad tracks on the Old Post Road several hundred yards southwest of the above-mentioned dump, showed that it bottomed in clays containing blue quartz pebbles characteristic of the nearby Precambrian. All of the area listed as Precambrian was very carefully searched for outcrop, and it is concluded that earlier mapping was based on information from well logs, just as in the case in this report, and on now-vanished outcrops.

Simultaneously with the field check operations, all well records on file in the office were consulted for the area between Trenton and Princeton Junction on either side of the Pennsylvania Railroad main line. The study of well records was made over an area sufficiently wide so that all areas which anyone had previously mapped as Precambrian, as well as those areas where there was reason to believe that the Precambrian was close to the surface, were encompassed.

Twenty-one well records were found adjacent to but outside of the areas formerly mapped as Precambrian. All of these wells first penetrate Pleistocene deposits of one kind or another. Some end in identifiable Precambrian rock, while others penetrate a few feet of either gray or yellow clay. In some of the records, this clay has been interpreted as Cretaceous. It is believed, in view of the material found in other wells in the general area which have penetrated thick sequences of Pleistocene and in view of the character of some of the clays observed at the surface in known Pleistocene deposits, that these clays in the above-mentioned wells are probably reworked Precambrian material. Some of the well logs for these wells were prepared by geologists, but others were prepared by the local drillers who are believed to have sufficient experience in the area to be able to identify the various geologic materials. Only those drillers' logs whose location was surrounded by reliable sample logs which had been described by geologists were used in the study and in the preparation of the geologic cross-sections.

West Windsor Township well 25, although a drillers' log, seems to indicate the existence of a Cretaceous filling in a channel in the Precambrian because the interval between 25 and 80 feet is described as white clay and white sand.

There is a lack of reliable subsurface information in the Great Bear Swamp area. Hamilton Township wells 73, 74, and 75 to the south and southeast of the swamp according to the drillers' logs may penetrate a thin section of Cretaceous before ending in Precambrian rocks. Hamilton Township well 76 appears to penetrate Pleistocene for its entire depth. The Precambrian-Cretaceous contact has therefore been arbitrarily located along the southern portion of Great Bear Swamp. A well drilled in November, 1960 after the revised contact had been drawn in was located just north of the inferred Precambrian boundary. The well struck dark green Precambrian schist at a depth of nine feet.

The shape of the Precambrian outcrop area beneath the Pleistocene suggests that, at several points, valleys or channels trending north-south, or northeast-southwest may have been eroded in the Precambrian basement. One such channel filled with Pleistocene may be indicated by West Windsor well 64 and 95 drilled for Wing Hing Farms. Other well records and geophysical traverses in the area suggest that there are other such channels which may have thin deposits of Cretaceous sediments, a thin residual layer of Triassic rocks, or uneroded weathered Precambrian material in the valley bottom. However, in most of this area between Trenton and Princeton Junction the Cretaceous or Triassic cover has apparently been eroded away until the Precambrian has been exposed and the valleys thus formed have been entirely filled with Pleistocene sediments.

Wells Tapping the Precambrian

In the study of the Precambrian rock area of Mercer County, 119 wells and test borings were plotted on the 1:2400 scale U.S.G.S. Quadrangle maps of the area. Of this group 26 domestic and 41 industrial wells were found to be getting their water from the Precambrian. Twenty other wells were drilled to the Precambrian but secure their water from the overlying formation.

Only four industrial wells in Ewing Township, all close to the Trenton City line draw from the Precambrian. Twenty of the Precambrian wells are industrial wells in Trenton. There are 17 domestic and 7 industrial wells in West Windsor Township all in or around Princeton Junction. The remainder of the Precambrian wells with one exception are in Hamilton and Lawrence Township within a mile of the Pennsylvania Railroad main line. The exception is an unsuccessful irrigation test well in Washington Township nearly three and a half miles south of the railroad.

Domestic wells tapping the joints and fissures in the Precambrian may be expected to yield about 10 gallons per minute from a depth of about 120 feet as shown on the tables below.

DOMESTIC WELLS

Township	*No. of Wells*	*YIELD IN GALLONS PER MINUTE* *Maximum*	*Minimum*	*Average*	*Median*
West Windsor	17	50	0	11*	7
Hamilton	4	20	1	9	4½
Lawrence	3	14 (6)	5	..	..
Trenton, City of	2	20	15	..	..

* 5 gpm without the 50 gpm and 30 gpm wells.

Township	*No. of Wells*	*DEPTH IN FEET BELOW SURFACE* *Maximum*	*Minimum*	*Average*	*Median*
West Windsor	17	350	52	111	91
Hamilton	4	205	135	169	203
Lawrence	3	123 (113)	65	..	..
Trenton, City of	2	194	36	..	..

Industrial wells in Mercer County drilled to the Precambrian have an average yield of 35 gpm. Only four out of 37 wells gave 100 gpm or more although nine others gave at least 50 gpm. It should be noted that four wells from 50 - 117 feet deep gave no water and one drilled to 448 gave only 2 gpm. There is no indication as to where the 100 gpm of water was struck in the 900 foot deep well for the Globe Rubber Works (Trenton #48), the deepest well in the county.

INDUSTRIAL WELLS

Township	*No. of Wells*	*YIELD IN GALLONS PER MINUTE* *Maximum*	*Minimum*	*Average*	*Median*
Trenton, City of	20	175**	0	38	16
West Windsor	7	266	17	86*	60
Lawrence	4	70	5	..	15
Ewing	4	40	1	..	30
Hamilton	5	60	7	..	15
Washington	1	..	Test	..	..

* See West Windsor Township.
** See Stokely-Van Camp below.

Township	*No. of Wells*	*DEPTH IN FEET BELOW SURFACE* *Maximum*	*Minimum*	*Average*	*Median*
Trenton, City of	20	900	50	365	360
West Windsor	7	393	103	266	283
Lawrence	4	350	59	..	304
Ewing	4	423	145	..	337
Hamilton	5	280	50	..	121
Washington	1	244	..	..	..

Among the well records considered for the tabulation in Mercer County was one, #23 in Trenton, an eight-inch diameter well drilled in 1912 for Stokely-Van Camp, Incorporated, about one-half mile from the Delaware River. The report indicates that this well was eight inches in diameter and was drilled 520 feet into the Precambrian rocks. It had a static level approximately equal to that of the Delaware River, and it is believed that it hit a very open fracture in the Precambrian which was directly connected to the river. The yield reported was 2,000 gpm with a 20-foot drawdown in a pumping test, whose duration is not indicated. In 1953 it was tested and allegedly gave 50 gpm. This well is so exceptional, for not only the Precambrian, but also for any rock formation, that it is not included in any tabulation.

Its reported yield is not given as the maximum Precambrian well, since this seems to be grossly exaggerated on the basis of the many wells that have been drilled in this type of rock. While such yields are possible in this type of rock or in sandstones or limestones, and indeed do occur at one or two locations elsewhere in the state upstream from Trenton in limestones, where the well is close to the Delaware River, such openings cannot be predicted and the probabilities of putting down any one well and intersecting such an opening are fantastically slim. A note on the well record indicates that the storage tank was filled in seven or eight hours of pumping. This indicates that the well was pumped at an actual rate of about 175 gpm. Even this rate is greater than any other Precambrian well in Mercer County.

As it is with most rock wells, so it is in the Precambrian wells of Mercer County; there is no correlation between depth and yield. The following table gives the yield in gallons per minute for fifty-foot increments of depth.

	YIELD IN GALLONS PER MINUTE	
Depth (feet)	*Industrial Wells (41)*	*Domestic Wells (26)*
0 - 50	0, 7½	20
51 - 100	0, 0, 60, no test	10, 30, 10, .., 0, 1½, 15, 10, 7, 5
101 - 150	11, 16, 20, 30, 15, 17	5, 50, 10, .., 4½, 12, 6, 14, 4½, 10
151 - 200	0	15, 18
201 - 250	Tested abandoned, 60, 70	20, 1
251 - 300	1, 15, 60, 47, 40	
301 - 350	60, 37, 5, 70, 20, 266, 25	5
351 - 400	40, 15, 150	
401 - 450	2, 85, 15, 40	

and also the following six industrial wells with the indicated total depth.

480′- 84 gpm, 520′- 175 gpm, 598′- 70 gpm, 713′- 25 gpm, 730′- 0 gpm, 900′- 100 gpm.

For the deeper wells there is no assurance that the water was not struck at some elevation well above the bottom of the hole.

TRIASSIC ROCKS

Rocks of Triassic age are exposed in eastern North America in several elongated disconnected patches roughly paralleling the Atlantic Coast from Nova Scotia to North Carolina. One of the largest, widest and most complex of these areas, which mark the position of the ancient Triassic valleys, extends from the Hudson River southwestward through New Jersey into Pennsylvania and thence westward and southward into Virginia. Within this area the strata are tilted gently (10° - 25°) to the north or northwest. The Piedmont Physiographic Province of New Jersey coincides with this area of Triassic rocks. Two-thirds of New Jersey's citizens live in the Piedmont which constitutes about one-fifth of the state. In Mercer County everything north of a line nearly coincident with the main line of the Pennsylvania Railroad lies within the Piedmont Physiographic Province.

The series was first named by Redfield in 1856 for the area around Newark. After detailed work prior to 1897 by H. B. Kummel, then State Geologist of New Jersey, the name "Newark Group" was generally accepted as standard for the Triassic rocks in North America. The Newark Group in most of the basins consists of two formations—a lower sandstone, or arkose, and an upper series of shales which are most typically red. Either basalt lava flows or, in the southern states, diabase sills or, as in New Jersey, both types of igneous rock are found interbedded with or intruding the sediments.

Along the Delaware River and in adjacent Mercer and Hunterdon Counties in New Jersey and in Bucks and Montgomery Counties in Pennsylvania exposures of the Triassic rocks are widest (about thirty miles) in the largest of the Triassic basins in eastern North America.

Within this area, also, are nearly all of the outcroppings of the Lockatong formation. As a result of recent geologic work in the area, it now seems debatable as to what is and what is not within the Lockatong formation or whether this rock type should be called a formation at all. Because the Lockatong argillite most obviously interfingers with and is of the same geologic age as the Brunswick shale, and because the Lockatong also interfingers with or has a gradational contact with the underlying Stockton, the term "lithofacies" has been applied (McLaughlin and Willard 1949) to the Lockatong argillite lithology. While the argillite is found as mappable units, its repetition and interfingering lead to difficulties when the time of deposition is considered, and an attempt is made to establish formational boundaries.

Such a delineation of the outcroppings of various rock types (as formations or as lithofacies), while each has some merits, becomes awkward in detailed mapping of an area such as Mercer County where there are several repetitions and interfingering. In this report, therefore, the Triassic is divided into and mapped as the Stockton sandstone, the Brunswick shale, and the Lockatong argillite. This procedure, while leaving the problem of formation names unresolved, permits the preparation of a geologic map, of geologic cross-sections and the discussion of the effect of lithologic variation upon ground water resources without ignoring field work done for this report, recent unpublished and uncompleted studies of the Lockatong rocks, or detailed studies of Pennsylvania geology which have recently been completed. Later, work may resolve the problem of formation boundaries and may slightly change the shape and size of the areas in Mercer County mapped as one rock type or another.

The Triassic basin begins near Stony Point, New York, on the west side of the Hudson. To the south and southwest, Brunswick shale is intruded by diabase and to the northwest is in fault contact with the Precambrian rocks of the Highlands. Fanglomerates and coarse conglomerates are found in the western part of the basin near the border fault. From Nyack, New York, southward the Stockton sandstone is found beneath the Palisades and southward of Piermont, New York, also above the intrusive sill. In the western part of the basin from near Oakland, New Jersey, southwestward to near Far Hills and Somerville, basaltic lava flows (which form the Watchung Mountains and several other high ridges) are found interbedded with the shales in the upper or younger part of the stratigraphic column. The eastern border of the Triassic is covered by overlapping Coastal Plain sediments from Bayonne southwestward to Princeton Junction where the contact of Triassic rocks with the older Precambrian and Paleozoic metasediments is infrequently exposed from beneath a veneer of Pleistocene deposits.

In contrast to the very thick apparently unrepeated stratigraphic sequence of several thousand feet of slightly folded and almost unfaulted northwestward dipping sediments and usually concordant igneous rocks, the New Jersey Triassic west of a line through Far Hills, Somerville and New Brunswick is much more intensely folded, is broken into several blocks by major faults which cause at least three repetitions of the stratigraphic sequence, and is intruded by a number of discordant igneous rock bodies. As mentioned above, this western part of the New Jersey Triassic basin has extensive exposures of Lockatong argillite. West of Far Hills the northwestern border of the Triassic is, characteristically, an unconformable contact with older rocks rather than a prominent border fault as is the case northeast of Far Hills. For several miles east of the Delaware River and at one or two other places in Hunterdon and Somerset Counties, faults again mark the northwest border of the Triassic basin. In Hunterdon County extensive areas of Triassic fanglomerate are found adjacent to the northwestern border.

In Mercer County the southeastern border is generally masked by Pleistocene deposits. However, outcroppings of Triassic, Stockton sandstone are frequently only a few hundred feet from areas known to be underlain by pre-Triassic rocks or from exposures of these rocks. The unconformable contact could at one time be observed near Princeton Junction. Construction work in and near Trenton has, in the past few years, created transitory exposures which have permitted the contact to be mapped more precisely. Geophysical work and well records in the border area suggest that at several places in Mercer County the Triassic is in fault contact with the underlying older rocks. The southeastern border of the Triassic is very close to the line of U. S. Route #1.

A normal stratigraphic succession of Stockton sandstone, Lockatong argillite, and Brunswick shale is found from Trenton and Princeton Junction northward to Moore and Hopewell. The Hopewell fault has caused an uplifted block of Triassic rocks to repeat the normal stratigraphic sequence a second time in northern Mercer and southern Hunterdon County. In the northern part of the first or Mercer County structural block, the westward extension of the Palisades diabase sill is found north of Princeton intruding and baking both the Brunswick shale and Lockatong argillite. West of Mount Rose the intrusion becomes more and more like a dike until it is terminated by the Hopewell fault. Four other diabase intrusions are found in Mercer County west of the Rocky Hill or Palisades sill before one reaches the Delaware River at Moore.

A small part of the diabase sill in the Hunterdon County block is found in extreme northeastern Mercer County. Beds belonging to the fanglomerates of northern Hunterdon County do not reach as far south as Mercer County. The basal Triassic exposed near Princeton Junction is a yellow, arkosic conglomerate with sizable quartz pebbles which apparently has been derived from the southeast.

In this report a number of changes have been made in the boundaries of all of the Triassic rocks as shown on earlier maps. All of these changes were made as the result of field checks by staff members of the New Jersey Geological Survey and other geologists working on problems of the Triassic in Mercer

County. The question of formation boundaries is left unresolved for the present. The major difference between the geologic map in this report and the 1950 geologic map of New Jersey is in the areas mapped as argillite or shale. The borders between the two types of rock and between the argillite and the Stockton sandstone may, as the result of later work, be slightly changed. However, the contacts between "formations" have always been described as, and are, transitional so that new exposures, well records or more detailed studies will modify the thickness and precise location of the bands of the various rock types. Each band of argillite shown on the Mercer County map also occurs west of the river in Bucks County (Dorf, 1951, Field Trip #2). In Mercer County each argillite area is topographically high, has a large number of poor wells, and some exposures of argillite rock. The interfingering with shale or sandstone and the lens-like form of the argillite bodies cannot be precisely portrayed on the map (Plate I) at the scale used in this report. In this report, however, each of the belts or bands of argillite shown contains a sufficient thickness of argillite to have an appreciable effect upon local ground water conditions.

Unrepeated by faulting or folding between the southern boundary of the Triassic basin and the Hopewell fault in Mercer County, the Triassic formations have the following approximate stratigraphic thicknesses:

Stockton sandstone	2,500′ – 3,300′
Main band of Lockatong argillite	1,000′ – 1,900′
All other bands of Lockatong argillite	900′ – 1,000′
Brunswick shale (including first or southerly band)	4,350′ – 4,850′
Less an overlap of the 2nd and 3rd bands of Lockatong with the Brunswick shale	500′ – 700′
Total Triassic Sedimentary Section in Mercer County	8,250′ – 10,350′
Palisades or Rocky Hill sill at Mt. Lucas (Princeton)	900′ – 1,300′

In northern Mercer County, the normal stratigraphic sequence is partially repeated north of the Hopewell fault. However, faulting and diabase intrusions in Hunterdon County complicate the geology and, therefore, the ground water conditions so that Mercer County is a better area than most parts of the state to study the difference in ground water conditions between the several Triassic formations.

The areas underlain by Stockton sandstone and Lockatong argillite are relatively small outside of Hunterdon and Mercer Counties. In the other New Jersey counties underlain by Triassic rocks, the Brunswick shale is the predominant rock type. Diabase and Stockton sandstone are found in Hudson and Bergen Counties, but most of the area is served by water companies and well records are relatively scarce.

Although about 90% of the areas in Mercer County underlain by Brunswick shale are found in Hopewell Township, the area of the township is large enough so that the wells completed in the shale may be compared to wells finished in the other Triassic formations. By comparing wells in the Hopewell Township shale areas with wells in Montgomery and Bridgewater Townships in Somerset County, it is possible to compare ground water conditions in a large area of geologically uncomplicated shale with a sizable area of shale which is interbedded with argillite, intruded by diabase and is, geologically, moderately complex.

In this report, wells in the Brunswick shale will be summarized for various areas of Hopewell Township and then compared with compilations of well records in Montgomery Township, and in two structurally different areas of Bridgewater Township. The wells in the Stockton sandstone and the diabase will be compared between townships. This will also be done for the Lockatong argillite, the wells in the several bands, and to a lesser extent wells in the argillite of southern Hunterdon County.

STOCKTON SANDSTONE

The Stockton sandstone is found in two areas of Mercer County. The main area of outcrop extends eastward from the Delaware River through the City of Trenton and the Townships of Ewing, Lawrence, Princeton, and West Windsor. It continues eastward into Plainsboro Township in Middlesex County. The second area lies north of the Hopewell fault where the Stockton sandstone is found on the north side of the fault from a point near Harbourton northeastward into Montgomery Township, Somerset County.

The main area underlain by Stockton sandstone is approximately thirty-five square miles in extent. The Stockton sandstone is exposed along the Delaware River for a distance of approximately three and three-fourths miles starting about one mile north of the Calhoun Street Bridge in Trenton. Along the Millstone River on the eastern border of the county the area underlain by sandstone is only about two and one-half miles wide.

There is reason to believe that in the western part of Mercer County (particularly in the vicinity of Wilburtha) one or more small faults may repeat part of the Stockton sandstone stratigraphic sequence. The Stockton sandstone in Mercer County is some 2,500 to 3,500 feet thick. It lies unconformably upon early Paleozoic and Precambrian rocks in the vicinity of Princeton Junction and Clarksville. The Stockton sandstone is also in fault contact with the underlying pre-Triassic rocks at several places which are buried by Pleistocene or Cretaceous cover. The upper or northern contact of the formation is usually gradational for about two hundred feet into the Lockatong argillite. However, in the vicinity of Ewing, West Trenton, and Scudders Falls there probably is a fault contact between the Stockton sandstone and the Lockatong argillite.

The second or Hopewell Township occurrence of the Stockton sandstone covers an area of a little more than five square miles. It is wedged out south of Harbourton by the Hopewell fault but rapidly widens eastward until it represents a stratigraphic thickness of 500 to 800 feet. Extending eastward into Montgomery Township of Middlesex County, it again is pinched out by the Hopewell fault within about one and one-half miles of the Mercer County line. This area of Stockton sandstone is topographically high forming the southerly slopes of the Hunterdon Plateau north of Hopewell and a high ridge south of Harbourton. The ridge of sandstone is traversed by Stony Brook in a narrow ravine about one mile northwest of Glen Moore. Although the Stockton sandstone, in general, is higher topographically than the Brunswick shale to the south and in places forms the southerly slopes of moderately high ridges, it is not as resistant to erosion as either the diabase intrusives or the Lockatong argillite which lie on either side of the sandstone between Harbourton and Hopewell Borough. As is the case in the main exposure of Stockton sandstone, the Hopewell Township occurrence has a gradational contact of about two hundred feet into the overlying Lockatcong argillite. In the area of this occurrence of the Stockton sandstone, most of the land is devoted to farms and country homes of several acres. There is no industry and there are only three wells which could be classified as industrial wells in the area. Two of these draw water from the fault zone of the Hopewell fault which forms the southern boundary of this area of Stockton sandstone.

In the main Mercer County area of Stockton sandstone there is a great deal of industry along U. S. Highway #1 and the Pennsylvania Railroad in the vicinity of Trenton and Penns Neck. Although there are still a great many areas still devoted to farms in Lawrence, Princeton, and West Windsor Townships, many areas are now or soon will be housing developments with either individual wells or wells supplying water to small water companies. There are some 77 industrial and public water supply wells drawing water from cracks, crevasses, and openings in this main Stockton sandstone area. The industrial wells completed in the Stockton sandstone have minimum yields of between 18 and 30 gallons per minute and average 100 gpm per well. The best well in the Stockton sandstone originally gave 905 gpm on a pump test.

There are some 149 domestic wells drawing water from the Stockton sandstone. Of these, only three give less than 5 gpm. Most domestic Stockton sandstone wells give between 5 and 20 gpm. Most of the wells are to be found in the more sparsely settled areas of Ewing, Lawrence, Princeton, and West Windsor Townships. Most of the more heavily populated areas are served by water companies which draw their water from wells in the Stockton sandstone. A large area underlain by Stockton sandstone is served by the Trenton Water Company which is supplied from the Delaware River, but within this water service area there are a number of small water companies which get their water from sandstone wells.

During World War II the experience of homeowners in the settlement of Penns Neck illustrated the difficulties which may be expected in areas underlain by "hard rock" formations when a major water user suddenly moves into or adjacent to an area already rather densely populated and relying on many individual wells for a water supply. Most domestic wells in the Penns Neck area were around 100 feet deep. A penicillin plant was erected just west of the settlement. Four deep, large capacity wells, which were pumped on a 24-hour basis, were completed in the Stockton sandstone. Very soon after this major industrial use of water started, most of the domestic wells in the settlement went dry. Protests were made without effect and many homeowners deepened their wells. The continued pumping of the formation proved unsatisfactory so that in less than two years the owners were forced to drill an additional well and finally a water supply had to be obtained from the Delaware and Raritan Canal approximately half a mile to the north of the plant site. At the present time only two of these wells are held in a stand-by condition, two have been abandoned, and one was never used. The ground water is no longer being overpumped and has probably returned to its former static level.

STOCKTON FORMATION

DOMESTIC WELLS

Township	*No. of Wells*	*YIELD IN GALLONS PER MINUTE* Maximum	*Minimum*	*Average*	*Median*
Hopewell	22	50	1	35	12
Ewing	64	60	5	17	15
Trenton	1	15	..	..	..
Lawrence	33	35	5	15	15
Princeton	11	60	12	26	20
West Windsor	17*	60	6	19	15

* No yield given for one well.

INDUSTRIAL WELLS

Township	*No. of Wells*	*YIELD IN GALLONS PER MINUTE* Maximum	*Minimum*	*Average*	*Median*
Hopewell	4	124 (50)	18 (40)	..	..
Ewing	18	207	50	121	110
Trenton	8	602	45	164	121
Lawrence	20	340	30	94	75
Princeton	3	905 (600)	200	..	..
West Windsor	27	700	25	165	100

STOCKTON FORMATION

DOMESTIC WELLS

Township	*No. of Wells*	*DEPTH IN FEET BELOW SURFACE* Maximum	*Minimum*	*Average*	*Median*
Hopewell	22	271	52	129	129
Ewing	64	670	22	108	..
Trenton	1	90	..	..	..
Lawrence	33	242	55	100	95
Princeton	11	190	85	140	131
West Windsor	18	188	52	97	85

INDUSTRIAL WELLS

Township	*No. of Wells*	*DEPTH IN FEET BELOW SURFACE* Maximum	*Minimum*	*Average*	*Median*
Hopewell	4	362 (251)	159 (243)	..	..
Ewing	18	603	150	274	205
Trenton	8	588	200	351	322
Lawrence	20	402	83	177	164
Princeton	3	583	302 (304)	..	..
West Windsor	27	518	40	269	300

ARGILLITE

About thirty-five square miles (13%) of Mercer County in the four northern townships (Hopewell, Ewing, Lawrence, and Princeton) are underlain by Lockatong argillite. As explained elsewhere in this report, the argillite is a rock type (lithofacies) in the normal Triassic stratigraphic sequence which is interbedded with, and is in part equivalent to, the Brunswick shale. Earlier workers mapped the argillite as a formation, and in this report it is so shown on maps and sections and so treated in the discussion. No attempt will be made here to solve this geologic problem; for simplicity the argillite will be treated as a formation.

On the maps and sections wherever there is a sufficient stratigraphic thickness of argillite beds to have an effect upon the ground water conditions, it has been shown as a formation. Within the areas mapped as argillite there are shale beds, small faults, and structures which cause some argillite wells to be better than average.

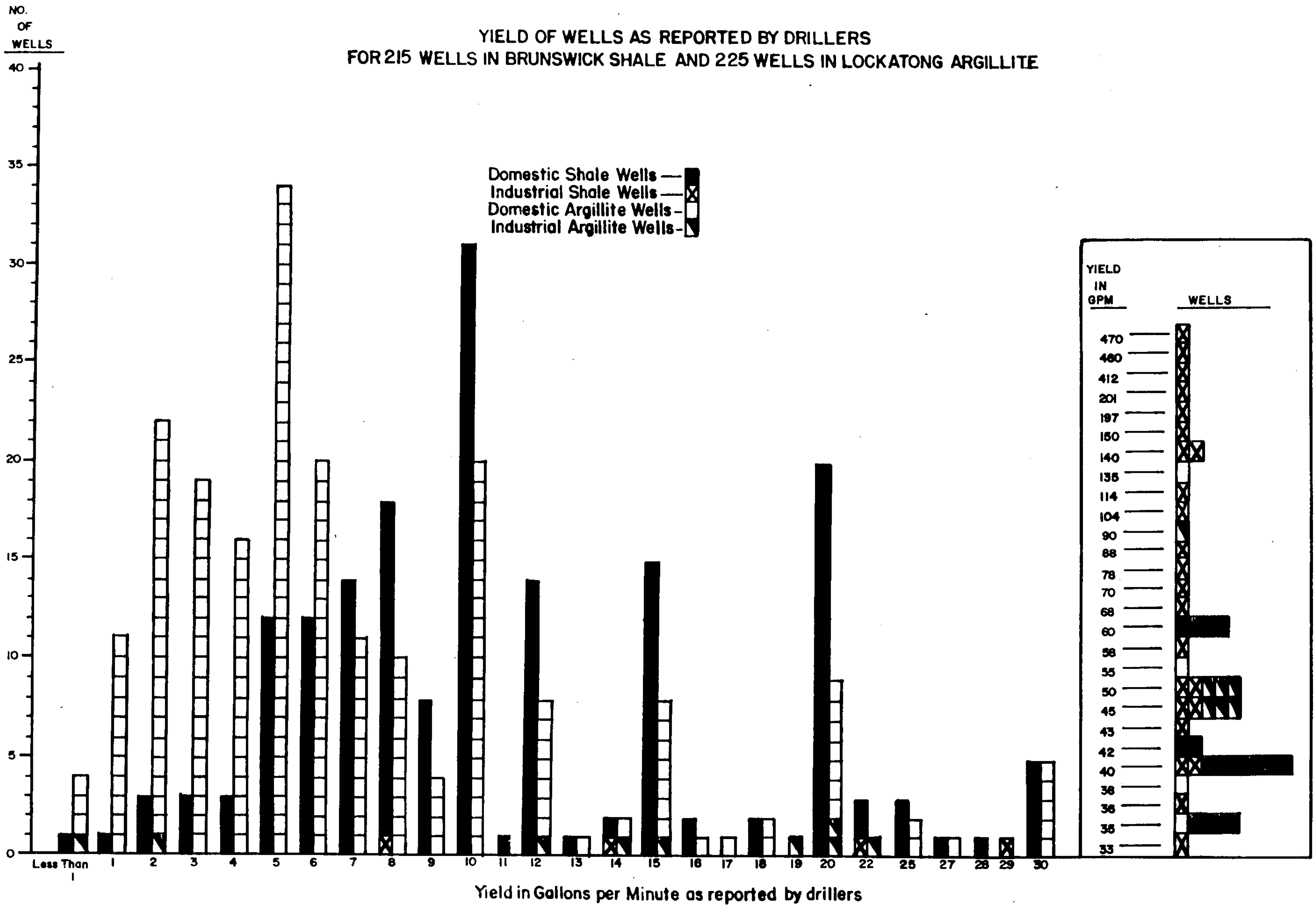
Within areas shown as shale, there may be occasional beds of argillite of limited extent. There will be a slightly reduced ground water potential and expectation for a number of homes or for a small housing development in such areas. However, while this may cause an individual problem, the effect will not be enough to warrant modification of the average values for wells in shale. Most contacts between the argillite and the Brunswick shale or Stockton sandstone are gradational with alternating beds of different lithology over a hundred feet or more of stratigraphic thickness. This transition can be most effectively observed in the road cut of Washington Road just north of Lake Carnegie as one approaches Princeton from the south. It is less obvious but can be observed in the pattern of surface outcroppings along Route #569 northward from Route #206 to Elm Ridge Road. This transitional contact has been recognized and reported by drillers in at least six well records located along the contacts shown on the map. These wells in the alternating transition beds of argillite and sandstone or argillite and shale, more often than not, are slightly better than the average yield for wells in either formation.

On the geologic map of the state and in some of the earlier works the Lockatong argillite is shown as a single formation between the Stockton sandstone and the Brunswick shale in Ewing, Lawrence, and Princeton Townships. More recent work by Van Houten (1962) and McLaughlin (1959) supplemented by field reconnaissance for this report suggests that the area previously mapped as argillite consists of a main area of massive argillite some 1,000 to 1,900 feet thick, a shale zone 400 to 600 feet thick (shown as Brunswick) and a second continuous but thinner (300 to 400 feet) argillite band. Where this argillite band is found in Princeton Township, it has, on occasion, been mapped and described as metamorphosed Brunswick shale because of its proximity to the Rocky Hill diabase intrusive. In the county tabulation of depth and yield, the two bands of argillite and all other occurrences are discussed as a single lithologic unit.

In addition to the two bands of argillite extending eastward from the Delaware River into Princeton Township, there are other areas in Hopewell Township underlain by argillite. The largest of these areas is in northern Hopewell Township and in adjacent West Amwell and East Amwell of Hunterdon County. Its southern border is the Hopewell fault as far east as Harbourton where it is conformably above Stockton sandstone. In central Hopewell Township, there are two belts of argillite extending eastward from the Delaware River to the vicinity of Pennington and to the vicinity of Glen Moore. The area underlain by argillite represents several hundred feet of stratigraphic thickness of argillite interbedded with very minor amounts of shale. Each of these separate areas of argillite has been analyzed in the Hopewell Township discussion, but all 116 wells drawing water from argillite in Hopewell Township are treated as a single unit.

Since the argillite is more of a ridge-former than the shale or sandstone, the areas underlain by argillite have proved to be attractive for residential development—generally with large expensive houses on fairly large lots. Except for the area of Princeton Borough which is served by a water company with wells outside the argillite area, there are no dense concentrations of people in the argillite area. West of Mercer County Airport over to the Delaware River south of Jacobs Creek and north of Scudders Falls, there are several realty developments which, up to the present time, have depended upon individual wells and septic tanks. There are similar concentrations of individual homes on moderate-size lots in Hopewell Township north of Ewingville and in argillite areas north of the village of Lawrenceville. Water problems in these areas are discussed in the Princeton, Lawrence, and Hopewell Township discussions.

The concentration of housing in argillite areas along the Delaware River in Ewing Township south of Jacobs Creek deserves particular attention. Approximately thirty of the Ewing Township domestic wells are found in this area. With two notable exceptions which may fortuitously be located on a minor fault, the wells are notably unsatisfactory, giving an average and a median which is just acceptable as a minimum requirement. In this area most of the home sites are on one to one-and-one-half acre lots. Over the years we have been asked to advise on problems of pollution, on where to locate a second well, and on what to do about sudden diversion of water from an existing well because a new well has been drilled next door. We also have one instance in which there was actual highjacking of a domestic water supply during a drought period. In this instance a neighbor wishing to fill his children's wading pool attached his hose to another neighbor's outside faucet, believing the neighbor would not be home until five o'clock. The neighbor arrived home early and, of course, was irate. Later in the evening when an attempt was made to do some laundry the domestic water supply had been so depleted in filling the wading pool that red silt was pumped into the washing machine.



NOTE: Due to a lack of space, the yield in gallons per minute of the better wells is continued in the vertical column to the right.

With respect to the other deficiencies of domestic wells drawing from the argillite, there are three or four domestic water systems in the area of discussion which because of pollution require chlorinators and probably nearly a dozen others which either should have them or will eventually be forced to install them. The writer has advised as to the location of a second well on at least three occasions in the area for homes where the original well was insufficient to meet domestic needs. In the last instance mentioned above, one of the home owners who was an early settler in the area had a very satisfactory well giving 10 gpm from 116 feet. Some twelve years after his home was built a new home was erected (in 1958) on the lot next door. The lots in this area were approximately one acre in size. The new neighbor did not get water until his well reached 628 feet at which time he secured 10 gpm and the original older well immediately went dry.

In an analysis of 225 argillite wells and 215 shale wells (both domestic and industrial) in Mercer County, we find that 33% of the argillite wells gave 4 gpm or less and may, therefore, be considered inadequate. Two of these wells were industrial wells. In contrast, only 5% of the shale wells gave 4 gpm or less and none of these were industrial wells. The comparison also shows that the lowest 10% of the argillite wells gave 2 gpm or less, whereas half of the lowest 10% of shale wells gave 5 gpm which is a minimum adequate supply. The lowest 50% of the argillite wells gave 6 gpm or less, whereas the lowest 50% of the shale wells gave 11 gpm or less.

Of the industrial wells drilled in argillite, half gave 20 gpm or less and the other half, with two exceptions, gave between 20 and 50 gpm. One domestic argillite well gave 135 gpm. In contrast, of the 30 industrial wells drilled in shale only three gave less than 20 gpm, while half gave in excess of 50 gpm with 5 giving 200 gpm or over.

Since only occasional argillite wells give more than 20 gpm, an effort was made to determine whether or not there was any geologic control over the better argillite wells. No certain pattern was developed, but four argillite wells giving 20 to 30 gpm in the vicinity of Woodsville were located close to a linear topographic feature which is not parallel to the strike of the argillite. In the previously described Mercer Airport and Ewing Township residential concentration to the west, nine argillite wells (including four industrial wells) were much better than average, giving from 20 to 90 gpm. Several of these wells are found to be on linear features and one giving 90 gpm is close to the contact between the Stockton sandstone and the Lockatong argillite which in this area is almost certainly a fault contact. The position of the other argillite wells giving more than 20 gpm suggests that the satisfactory argillite wells are dependent upon minor faults, major joints, and perhaps lenses of interbedded shale, all of which will result in more frequent, more open, and more closely spaced fractures than can be found in the normal argillite.

LOCKATONG ARGILLITE

DOMESTIC WELLS

Township	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
		YIELD IN GALLONS PER MINUTE			
Hopewell	115*	35	¾	7	5
Ewing	35	20	1	5	5
Lawrence	32	30	2	10	7
Princeton	26	55	⅕	8**	6

* One well 135 gpm from 116′ not included.

** Average of 25 wells without 55 gpm wells is 6 gpm. One-third of wells give 3 gpm or less.

INDUSTRIAL WELLS

Township	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
		YIELD IN GALLONS PER MINUTE			
Hopewell	4	50	½	29	..
Ewing	4	90	12	39*	..
Lawrence	6	50	2	25	..
Princeton	2	50	38	..	..

* Average of three wells 23 gpm.

LOCKATONG ARGILLITE

DOMESTIC WELLS		*DEPTH IN FEET BELOW SURFACE*			
Township	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
Hopewell	116	400	48	153	130
Ewing	35	798	62	159	123
Lawrence	32	350	50	147	125
Princeton	26	610	77	218	175

INDUSTRIAL WELLS		*DEPTH IN FEET BELOW SURFACE*			
Township	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
Hopewell	4	413	120	241	..
Ewing	4	436	123	298	..
Lawrence	6	327	208	256	250
Princeton	2	300	85	..	..

BRUNSWICK SHALE

Most of the Brunswick shale is a very fine-grained, thin-bedded, bright red, argillaceous shale which will quickly weather into thin flakes or flat angular fragments and eventually into a soft, sticky, red mud. Some siltstones and occasional beds of black, gray, greenish or bluish shales are found. Adjacent to the diabase intrusions the shale is a uniform, gray weathering, hard hornfels. In the older reports, such as the Raritan Folio and Bulletin #50, lithologic characteristics found in the argillite are also attributed to the Brunswick shale. In studies by McLaughlin, the Brunswick formation is mapped and described as containing red and dark gray argillite members and the Lockatong formation is mapped and described as including some red shales.

Older descriptions of the Brunswick formation mention abundant plant fossils as being found, but these may properly belong to the interbedded argillites. Dinosaur footprints and some skeletal material from vertebrates have been found in the shale beds of the Brunswick formation. Fossils, however, are extremely rare in the shales as are distinctive minor structures such as bedding, ripple marks, mud cracks, and rain drop impressions. All are described as belonging to the shales of the Brunswick formation, but more recent work suggests that most of these would seem to be more commonly found in the argillite beds.

Areas underlain by shale are topographically low. Outcroppings decompose rapidly to a slumped bank of mud and fragments. Fresh red argillite and red shale are at first glance easily confused, as many a homeowner who sought to use slabs of rock excavated from his basement for a garden wall has found to his sorrow. In from two to four years the pieces of shale or siltstone will crumble to a mass of small fragments. Areas of heavy red clay soil without exposures of rock are apt to be areas underlain by shale. Outcroppings are more frequently argillite or sandstone. The depth to which the shale is weathered depends not only upon the slope, but also upon the presence or absence of Pleistocene surficial deposits. In general, the Brunswick shale will be easily broken up to depths of seven to ten feet where land slope is not a factor. In well drilling, twenty to thirty feet of casing is in order most of the time. Cuttings will produce a sticky mud to a considerable depth and may "mud-off" small amounts of water in cracks near the surface. Drillers become more hopeful of water when harder beds are hit or when "white spots" appear. These "white spots" would seem to be calcite in shale or analcime in the interbedded argillite.

Nearly ninety percent of the area underlain by shale in Mercer County is to be found in Hopewell Township. Within Hopewell Township, shale underlies slightly more than fifty percent of the total area and all of this, except two or three square miles in the southern part of the township and less than a square mile west of Woodsville, is found beneath the lower ground through the central part of the township from the Delaware River northeastward to Pennington, Hopewell, and beyond into Montgomery Township. From the point of view of area and the availability of well records, ground water conditions in the Brunswick shale of Hopewell Township are the ground water conditions to be found in this formation in Mercer County.

The Brunswick shale, for all practical purposes, is an impermeable rock. Water is derived from cracks and fissures whether they be joints, bedding planes, or faults. The more frequent and open the joints, the more severe the faulting with related shattering of the rock, or the more variation between hard or competent beds and soft or less competent beds in slightly folded rocks, the greater the probability of being able to drill and bring in successful wells with higher than average yields. On the other hand, intrusion by diabase with its accompanying baking and metamorphism, interbedding with appreciable thicknesses of argillite, or folding or other deformation of less competent shales between thick bands of competent strata may reduce, seal, or otherwise eliminate the number or openness of cracks and fissures in the rock and thereby reduce the reasonable expectations of the quantity of ground water which may be secured from wells.

All of these varying conditions are illustrated in the three areas of Brunswick shale found in Hopewell Township. There are no wells in the small area of shale in Hopewell Township west of Woodsville on the northern border of Mercer County. Stratigraphically above a thick argillite zone, it is intruded by diabase on the north in East and West Amwell Township in Hunterdon County and is, in part, baked by the intrusion. It is also a relatively narrow belt of shale between two broad bands of more competent rock. Seven available well records in West Amwell Township indicate yields of from 2½ gpm to 9 gpm with an average and median yield of 4 gpm. Depths range from 108′ to 200′ with an average depth of 135′. Although the depths of the wells are about average or slightly less than in Hopewell Township and Mercer County, the reported yields are all very low and with an average and median yield of less than half of what may normally be expected.

The second area underlain by the Brunswick shale in Mercer County is chiefly in southern Hopewell Township. It extends as a narrow belt of shale between two much thicker bands of argillite from the Delaware River northeastward through the northern tip of Lawrence Township into Princeton Township and continues into Somerset County just north of the village of Kingston. Two domestic wells in Lawrence Township, eight in Princeton Township, and twenty in Hopewell Township tap water-bearing fissures in this belt of shale. Also found in this band of shale are three of the Hopewell Township industrial wells and the five industrial wells in shale in Princeton Township. The domestic wells are all average and conform to the over-all pattern in every way except that a slightly higher number of minimum producers giving around 5 gpm are offset by few wells giving 15 gpm or more. The three industrial wells in the Bristol-Myers tract in Hopewell Township and the five industrial Princeton Township wells include seven of the top ten yields for industrial wells in shale in the county. All are eight inches in diameter or larger and have a range in depth rather evenly distributed from the third shallowest to the deepest but one.

The better-than-average yield for the industrial wells in this belt of shale may be accounted for by two conditions as compared to the other industrial wells in shale in Mercer County. All have been drilled in the last ten years and at least five were located by geologists using their knowledge of local structural conditions to try to make the wells intercept major joints or minor faults.

Of the domestic wells in this belt of Brunswick shale, 13 (#250 - #262) were drilled during 1960, 1961, and 1962 for a realty development in Hopewell Township on the Lawrenceville Road in an area about 500 - 700 feet north and stratigraphically above the approximate top or northern contact of the main band of argillite. Of these wells, nine are from 75′ to 125′ deep and are reported as giving 20 gpm from 75′, 16 gpm from 98′, 12 gpm from 106′, 25 gpm from 115′, 5½ gpm from 123′, and notice, 8 gpm from 124′, on two occasions, and 5 gpm from 125′. The remaining four wells are the poorest in the group and all are in excess of 183′ deep, giving 4 gpm from 183′ and from three wells, each 225′ deep, 3½, 2½, and 5 gpm. The yields, depths and location relationships suggest that the wells over 125′ deep are completed in the underlying argillite.

A similar local geologic relationship is found in the case of wells #267 - #288 for a Washington Hills Development on the Pennington-Titusville Road. Even discounting over-optimistic reports of yields from the particular driller who constructed most of the wells, all are adequate from the 10 gpm at 142′ down to 60 gpm at 240′. With three exceptions, the 17 wells in this depth range give in excess of 10 gpm; the three exceptions give 7 gpm from 160′ and 175′ and 9 gpm from 175′. In this group the three largest producers reported are 60 gpm from 240′, 42 gpm from 175′ and 40 gpm from 215′. However, of the five deepest wells, four drilled to a depth of 250′ give 8, 7, 15, and 1½ gpm; and one drilled to 257′ is reported as giving 2 gpm. Again, in this instance, the wells have been drilled just north of an argillite band which forms a prominent ridge extending eastward from the Delaware River for about two miles to Jacobs Creek and then as a less distinct ridge eastward beyond Jacobs Creek to the high ground northwest of Pennington, suggesting that the deeper wells with low yields were completed in argillite.

The remaining 134 domestic wells and 20 industrial wells in Hopewell Township are scattered throughout the area underlain by shale with the majority sufficiently far away from the upper argillite contacts so that the argillite will not be encountered at any reasonable depth. In western Hopewell Township (west of Route #69), two large diabase intrusions and three bands of argillite, two of which have already been mentioned above, are found dividing the broad belt of Brunswick shale into several smaller areas. East of Pennington and Glen Moore, the argillite bands die out and the shale in the eastern part of the township is only interrupted by the intrusion of the Rocky Hill diabase and the small intrusive plug of diabase near Glen Moore.

Included in the 134 wells mentioned above are 28 wells in a development along Dublin Road just west of Pennington. All the wells have been completed in, and the entire tract is underlain by, typical red Brunswick shale. The wells, in depth and yield, are as good as any other group as indicated in the summary of Hopewell Township domestic wells which gives the statistics for the five groups of wells mentioned in this discussion. The well records are all from more reliable drillers and most are from one driller whose reports are known to be reliable. Each house has an individual well and septic tank system. The building lots in the development range in size from one-half to two-thirds acre or slightly more. Although not all wells were considered in the sample, those included cover wells for houses in the first unit built in 1954 and wells completed in 1961. In this eight year period, the depths of the wells in the area have increased from the 134′-165′ range in 1954 to the 175′-249′ range of 1961 and reported yields have dropped from an average of 15 gpm in 1954 (6-28 gpm range) to a 10 gpm average in 1961. During the summer of 1962 one family in the first section of the development had to deepen their well and a second lowered the intake.

A comparison of the Mercer County shale wells (given at the end of this section), with groups of similar wells in Montgomery Township bordering Mercer County on the northeast and Bridgewater Township further east in Somerset County, shows that, because of the diabase intrusions and more complex structure and stratigraphy, the Mercer County domestic wells are slightly deeper, are spread over a greater range of yields, and have a slightly higher percentage of low yields than is the case with the wells in wide areas of shale uncomplicated by argillite, intrusions of diabase or basaltic lava flows.

The depth and yield figures for wells in the shale of Washington Valley in Bridgewater Township, which lies between the two more competent bands of the Watchung basalts, indicate that the average ground water conditions there are almost identical to those found in the Brunswick shale in Mercer County where the shales are intruded by diabase or are found between bands of argillite.

A comparison of industrial wells in the several shale areas (because of geographic factors, the greater range in diameters, and the smaller size of the sample) is not as significant as a comparison of domestic wells. However, such an industrial well summary is included at the end of this section.

In attempting to solve individual well problems and give reasonable accurate answers as to reasonable expectations of depth and yield, the characteristics of depth and yield reported for the nearest wells are, of course, used when checking against the local subsurface conditions. However, the question often arises as to how large a sample is necessary in order to secure at least some of the best and some of the worst yields. Five wells would not seem to be an adequate sample; ten wells give a general indication of what may be expected. A sample of at least twenty wells would seem to be the minimum size desirable, if the effects of several common variables are to be reduced. In order to come up with reasonable expectations as to maximum, minimum, averages and probabilities, the several compilations seem to indicate that a desirable sample size for any township analysis is in excess of fifty wells. Put in a different way, local variations in any one square mile may seriously affect the results of any statistical summary unless the results are compared against samples of adequate size from other nearby areas. The two tabulations given at the end of this section illustrate some of the problems involved in securing a significant sample of well records.

Because of the large size of the sample of well records used in Hopewell Township, three additional comparisons would seem in order: (1) depth-yield; (2) diameter-yield relationships; (3) percentage of wells in the various yield ranges.

With respect to depth and yield, the twenty-nine industrial wells completed in shale were tabulated in order of depth from the deepest (800′) to the shallowest (150′) with the following results:

Diam. (Inch.)	*Depth (Feet)*	*GPM*	*Diam. (Inch.)*	*Depth (Feet)*	*GPM*
6	800	29	8	512	40
10	708*	140	8	501	33
10	657	45	6	500	43
12	572	88	10	422	470

* The 708′ well got its water at 230′. If this comparison indicates anything, it would seem to be that drilling a well to depths of over 500′ is hardly worthwhile and that drilling to a depth over 200′ is desirable unless a yield of 50 gpm or more has been secured at a lesser depth.

Diam. (Inch.)	Depth (Feet)	GPM	Diam. (Inch.)	Depth (Feet)	GPM
10	407	14	6	228	8
12	403	197	8	201	50
8	400	78	8	188	104
10	393	460	6	186	50
8	300	45	6	183	11
6	300	412	8	179	140
8	300	70	10	178	22
8	300	68	10	178	22
10	273	201	6	159	40
8	250	36	6	150	150
8	230	114			

A tabulation by yield with the diameter of the well given in the second column suggests that 8″ or 10″ diameter wells may be more successful than a 6″ well. Perhaps, however, since it is the size of the fracture that is the governing factor, the large diameter permits a greater yield if the fracture is there in the first place.

Industrial Wells in Hopewell Township
Diameter in Inches Compared to Yield in Gallons Per Minute

Diameter In Inches	10″	8″	6″	10″	8″	6″
	470	..	..	..	..	68
Yield	460	..	..	..	50	50
	...	412	..	45	45	43
In	201	..	..	..	40	40
	*	...	..	38	..	..
Gallons	..	..	150	..	36	..
	140	..	..	..	33	..
Per	..	114	..	..	..	29
	..	104	..	22	..	..
Minute	..	78	..	14	..	..
	..	70	..	..	..	11
				..	..	8

* A 12″ well gave 197 gpm.

Using the reported yield of the 200 industrial and domestic wells in Hopewell Township, we find two-thirds of the industrial wells are in the top 10% of yields. This might be expected. One industrial well, however, is in the lowest 10% of all yields. Twenty percent of the wells give 30 gpm or more and 20% give 7 gpm or less with only 5% giving less than 5 gpm.

BRUNSWICK SHALE DOMESTIC WELLS

Township	*No. of Wells*	*YIELD IN GALLONS PER MINUTE* *Maximum*	*Minimum*	*Average*	*Median*
Hopewell	176	60	½	15	10
Princeton	8	30	5	11	8
Lawrence	2	7	5	..	..
All Shale (Mercer Co.)	186	60	½	15	..
Montgomery	43	40	3	13	14
Bridgewater					
a. Washington Valley	95	25	8	12	10
b. South of 1st Watchungs	144	35	2	13	12

INDUSTRIAL WELLS

Township	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
		YIELD IN GALLONS PER MINUTE			
Hopewell	24	412	8	76	50
Princeton	5	470	88	271	197
Lawrence	..	..	..	..	..
All Shale (Mercer Co.)	29	470	8	110	50
Montgomery	15	296	22	100	106
Bridgewater					
a. Washington Valley	4	(50, 50, 30, 20)			
b. South of 1st Watchungs	46	664	32	183	137

NOTE: Montgomery and Bridgewater Townships are in Somerset County.

BRUNSWICK SHALE

DOMESTIC WELLS

Township	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
		DEPTH IN FEET BELOW SURFACE			
Hopewell	176	397	45	154	145
Princeton	8	350	98	210	181
Lawrence	..	204	131	..	..
All Shale (Mercer Co.)	156	397	45	156	..
Montgomery	43	251	90	146	139
Bridgewater					
a. Washington Valley	95	205	84	131	130
b. South of 1st Watchungs	144	300	77	135	152

INDUSTRIAL WELLS

Township	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
		DEPTH IN FEET BELOW SURFACE			
Hopewell	23	800 (708)	150	283*	300
Princeton	5	572	179	394	403
Lawrence	..	..	..	..	..
All Shale (Mercer Co.)	..	800	150	349	300
Montgomery	16	532	100	290	303
Bridgewater					
a. Washington Valley	4	(350, 300, 300, 165)			
b. South of 1st Watchungs	47	707	128	343	310

NOTE: Montgomery and Bridgewater Townships are in Somerset County.

* Well 800′ deep not included.

DIABASE

Six intrusions of diabase are found in the northern part of Mercer County in Hopewell Township; only one, the westward continuation of the Rocky Hill or Palisades sill, is found outside Hopewell Township in adjacent Princeton Township. Approximately twelve square miles of Mercer County is underlain by diabase. The diabase areas are usually wooded and, topographically, noticeably above the surrounding countryside. For the last several years in Princeton Township and where the diabase is crossed by roads in Hopewell Township, there has been considerable home building. Ground water conditions in diabase areas are such that wells are frequently inadequate; septic tanks often break out and occasionally wells become contaminated a few years after initial construction.

There are no industrial wells drilled in diabase in Mercer County or in adjacent townships to the north or east. Records were examined for fifty-five Mercer County domestic wells that were completed in diabase. There are no wells in the most westerly diabase plug at the Mercer County Work House. Eleven wells (about a third of the homes) were checked on Baldpate Mountain. Records were used for seven wells on Pennington Mountain and in the small plug at Moore. Twenty wells in Princeton Township and eleven wells in Hopewell Township were completed in the diabase sill.

The largest area underlain by diabase is the Rocky Hill sill found in Princeton Township and in northeastern Hopewell Township. The sill has an outcrop area nearly a mile wide and a low angle (14°) northerly dip in the Mt. Lucas area of Princeton Township. West of Province Line Road and in Hopewell Township the dip steepens and the diabase cross-cuts the shale, becoming a dike from Mt. Rose westward. The intrusion is abruptly terminated by the Hopewell fault. In Hopewell Township all homes in the area underlain by diabase rely on their own wells, in Princeton Township a considerable area of the ridge is served by the Princeton Water Company.

In the northern tip of Mercer County, north of Hopewell, there is an outcrop area of the Sourland Mountain sill which is also found in adjacent East and West Amwell Townships in Hunterdon County and Montgomery Township in Somerset County. Records from five wells completed in this diabase mass in Hopewell Township are included in the summary. In Montgomery Township to the east, there are no well records from the diabase. In East Amwell Township, this diabase sill is found both to the north and east and to the west of the outcrop area in Hopewell Township. The entire area is sparsely settled and heavily wooded. In the summary of diabase wells, seven wells from East Amwell Township and ten wells from West Amwell Township (most in the vicinity of Lambertville) completed in this Sourland Mountain sill are included, for comparative purposes.

It is believed high-cost-per-foot for wells drilled in diabase influences the statistical picture. The cost-per-foot, when a cable tool rig is used for a well in diabase, is two or three times the cost-per-foot for a well drilled in shale. Many drillers will only give an hourly rate for diabase drilling and the cost-per-foot in several instances has been unbelievably high. Rotary rigs are faster and seemingly cheaper when used in diabase. Because of this, the well in diabase is apt to be drilled much deeper than any well drilled with a cable tool rig. The homeowner, therefore, does two things when contracting for a well in diabase: First he is willing to accept a smaller amount of water, and second, he will accept the first water found. If his well were drilled with a cable tool rig, he may give up before water is found, even at a relatively shallow depth, because of the high cost of drilling. On the other hand, with the rotary rig the tendency to go deeper to try to get more water is increased. Where the well record shows no water or very little water, the homeowner may already have, or may construct a large diameter hand-dug shallow well. He will rely on his neighbors for water in the late summer and at a later date he may again contract for a drilled well. A drilled well, which will not go dry in the summer and the hope for a yield which will permit him to be less saving in his use of water is the goal of each homeowner living in an area underlain by diabase.

In view of the above, it should be noted that while the range in depth and yield for domestic diabase wells is much the same as for domestic wells drilled in the argillite areas, the average and median depth of diabase wells is less than the shale wells—apparently because of the above mentioned attitude of the homeowner. The difference in depth would be greater if the usually-much-deeper rotary holes were not included in the average.

The probabilities of securing large amounts of water from wells drilled in diabase are slim indeed. If the well intersects a fault or a large open joint, 100 gpm more may be obtained, but only 10% of the diabase wells give in excess of 10 gpm in contrast to 60% of the shale wells giving 10 gpm or more.

There are no industrial wells in diabase in Mercer County or in the two townships in Hunterdon County used in this summary.

DOMESTIC WELLS		*YIELD IN GALLONS PER MINUTE*			
Township	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
Hopewell	35	27	½	8	6
Princeton	20	100	0	16*	4**
East Amwell (Hunterdon)	7	5	¼	2½	2
West Amwell (Hunterdon)	10	15	0	4	1
For comparison:					
Brunswick Shale (Hopewell)	176	60	½	15	10

* Average of 18 wells without 100 gpm and 60 gpm wells is 6 gpm.
** One-half of the wells give less than 4 gpm.

DOMESTIC WELLS		*DEPTH IN FEET BELOW SURFACE*			
Township	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
Hopewell	35	404	50	128	100
Princeton	20	338	50	139	108
East Amwell (Hunterdon)	7	351	42	116	..
West Amwell (Hunterdon)	10	200	48	95	90
For comparison:					
Brunswick Shale (Hopewell)	176	397	45	154	145

Median and average yields are about half as good in diabase as they are in the Brunswick shale. In diabase 40% - 50% of the domestic wells are inadequate (less than 5 gpm) in contrast to 5% for such wells in shale.

TOPOGRAPHIC EXPRESSION OF MINOR GEOLOGIC STRUCTURES

Faults, joints, and stratigraphic variations often show as linear topographic features in areas when surficial cover is thin or the depth of weathering is shallow. In the areas of northern Mercer County underlain by the Brunswick shale, argillite, diabase, and in some of the area underlain by Stockton sandstone, bedrock is sufficiently close to the surface so that linear topographic features giving surface expression to the underlying geologic conditions are nearly always present. In southern Ewing, Lawrence, and Princeton Townships thick deposits of Pennsauken or "Trenton" gravels conceal these features on the bedrock surface. In southern Mercer County the Pleistocene and Cretaceous sediments are capable of producing sufficient water so that the detailed structures of the underlying crystalline rocks are only of academic interest.

In the solution of several problems for industrial or municipal water supplies in the northern part of Mercer County, efforts were made to locate the wells along and in these linear features as indicated by intermittent streams, swales, or other alignments of topographic features. The mile-to-the-inch State Atlas sheets, the 1:24,000 Federal quadrangle sheets, aerial photographs, and field visits have been utilized in locating specific wells along linear features. There has been sufficient success in the actual practice to suggest that this is a valuable way of locating wells in areas where the bedrock is not concealed by surficial deposits, deep weathering or Coastal Plain sediments. Recent work with aerial photographs suggests that, even with a thick cover of unconsolidated materials, major features of the underlying bedrock may be reflected at the surface.

In order to test the significance of linear features, ninety-one of the best wells and twenty-eight of unusually poor wells were plotted on an overlay for the mile-to-the-inch topographic map in northern Mercer County. A geologist who had not worked on the well problems prepared a second overlay showing the linear features in the same area as indicated by the topographic map. The overlay of linear features was then placed on the overlay of the wells. The number of wells that were on or within the zone of influence of the linear features were counted. A well more than an eighth of a mile off of the linear features was considered as one which would not be affected by the linear, whatever its nature. It is believed the results obtained are significant. Of 15 industrial wells which were exceptionally good, 13 or 87% were found to be located on linear features. Of these 15 wells, 8 were in the Stockton sandstone, 3 were in the Lockatong argillite, and 2 were in the Brunswick shale. One of the Brunswick shale wells was on the shale-argillite contact and one of the exceptional argillite wells was not apparently related to any linear topographic feature.

Of the low-yield industrial wells which were considered, only three wells, all in the Brunswick shale, were on the linear features. The remaining ten (four in the Brunswick, ten in the Lockatong, and two in the Stockton) were not related to any linear feature.

Fifty-two of the better domestic wells out of 76 considered, or 68%, fell within the area of the linear features. Six were on or close to geologic contacts between the Brunswick shale and the Lockatong argillite. Only 18 of the better wells (nine in the Brunswick, five in the Lockatong, and four in the Stockton) were not found to be related to any linear feature. Twenty-six out of twenty-nine poor domestic wells were found to be unrelated to linear features. Only three (two in the Brunswick and one in the Lockatong) were found to be on or in the specified zone of influence of the linear features. Considering all of the domestic wells, ninety-five percent of the domestic wells on linear features are much better than average.

The major faults in northern Mercer County are marked by abrupt topographic changes or by deeply incised valleys. In Hopewell Township wells #61 and #62, with exceptionally high yields, drilled for the Hopewell Borough Water Company (see Hopewell Township discussion) and #164, #172 and #173 drilled for the Pennington Quarry Company and Pennington Borough with moderate yields have been completed in fault zones with marked topographic expression. Four of the better argillite wells in Hopewell Township, #117, #188, #189 and #361 (yields of 30, 30, 27, and 20 gpm respectively), are in such alignment and so located that a fault or major joint without topographic expression may be suspected. Ewing well #89 for State Police Headquarters is in a fault zone without topographic expression as shown by the well cuttings which contained fault gouge and calcite vein filling. The yield is exceptionally good.

The surface expression of major joints or closely spaced joints is more frequent than is generally realized. Swales on the ground, parallel darker lines on aerial photos, and the alignment of streams or swales across one or more ridges are indicators of major joints or concentrations of joints that have been utilized to locate better than average wells. In this group are wells #95 and #100 for Bristol-Myers in Hopewell Township, wells #175 and #179 for Pennington Borough (Hopewell Township summary), #207 and #209 for Western Electric (Hopewell Township), #1 through #4 for Educational Testing Service (Lawrence Township) and other wells which usually have very high yields.

Outcroppings on the west side of Stony Brook near Pennington show closely spaced joints at either end of a half mile section. Wells #179 and #156 to #161 are parallel to this bank in the order given starting with #179 at the north end. In the same order the wells give 38, 60, 12, 15, 15, 9, and 40 gpm. The largest yields are opposite and in line with the jointing that is most closely spaced.

In contrast to the above, open joints are not always desirable. When the first well for #159 was drilled it intersected an open joint at about 125 feet which was apparently directly connected to Stony Brook. The water was equal to that in the brook in every way—smell, color, turbidity, temperature, and algae. The well was filled with cement and a new well, #159, was drilled at the diagonally opposite corner of the house. The house is about 100 yards west of and some thirty feet higher than Stony Brook.

Two other wells illustrate dramatically the importance of major open joints. Hopewell #177 was located near the center of a topographic block bordered by pronounced swales and minor streams. The ten-inch well for the Pennington Water Company was abandoned at 407 feet depth when it only gave 14 gpm. The case of Ewing #4, a 568-foot-deep well, is described in the argillite discussion. Here the same joint utilized by an earlier well at a lesser depth was tapped and drained by the deeper well when it reached its full depth.

In Hopewell Township the alternation of thicknesses of argillite and shale in the stratigraphic column give the topography a ribbed appearance with ridges parallel to the strike of the formations. A number of linear topographic features are therefore due to a change in the type of rock and follow the geologic contacts. Hopewell wells #15, #162, #52, #90 and #40 are all in the top third of the sandstone yields; each of these wells is in the transition zone from sandstone into argillite and in many instances the drillers have reported this variation as "hard and soft" rock layers. The importance of the change in geologic formations and the way in which it seems to affect the yield of wells is illustrated and discussed with respect to two housing developments in Hopewell Township. The deeper wells completed in argillite are notably poorer than the shallower wells completed in shale.

Folding is slight in the formations of northern Mercer County. Most of the strata have a monoclinal dip to the northwest. While it may be presumed that folds have an effect on ground water they would seem to be unimportant in this area.

Diabase intrusions, as a sill and as plugs, form several "mountains" or "ridges" in northern Mercer County. The bordering shales and argillites are usually metamorphosed and give less water than normal unless unaltered shale can be reached below the sill. Hopewell #208 for Western Electric near the Rocky Hill sill was driven deeper than would normally be expected until it penetrated the underlying less metamorphosed shale. The effect of jointing within the plugs is discussed in the Diabase section. At a number of places better than usual diabase wells can be correlated with topographic lows which seem to mark faults in the diabase ridge. Princeton #1, the best of all diabase wells, apparently is either unrelated to geologic structure or is a well crossing a bedding plane fault along a formation contact.

Experience of the staff of the New Jersey Survey seems to indicate beyond all doubt that careful attention to the minor geologic structures in an area "pays off" when used in locating wells. Small yields can often be secured in difficult areas and larger yields at lesser depths seem to be more probable when topography is used to indicate the more important local geologic structures.

COASTAL PLAIN FORMATIONS

The southern 40% of Mercer County, some 92 square miles, is within the New Jersey section of the Coastal Plain Physiographic Province. The Coastal Plain contains Upper Cretaceous and Tertiary sediments which dip toward the ocean from an inner margin along a line which nearly coincides with that of the Pennsylvania Railroad from Trenton to east of Princeton Junction.

Six of the eleven Cretaceous formations of the Coastal Plain underlie Mercer County although exposures are found only along the steep banks of major streams where the drainage is incised into the very flat Coastal Plain topography. Nearly all of southern Mercer County is covered by Pleistocene sands and gravels which have filled all the pre-Pleistocene and early Pleistocene valleys which were cut in the Cretaceous formations. The Pleistocene sediments have effectively buried the Cretaceous formations, except as noted above, as far south as the area underlain by the Englishtown formation in extreme southern Mercer County.

The lower-most Cretaceous formation, the Raritan, rests unconformably on a surface of low relief composed of Precambrian, early Paleozoic, and Triassic rocks. Wells indicate that this surface of older rocks has a relief of nearly two hundred feet. The Raritan formation consists predominately of light colored sands and clays which vary rapidly in color, sorting, and grain size, both vertically and horizontally, throughout their thickness. Disconformably above the Raritan, and in wells extremely difficult to differentiate, is the Magothy formation which is from 25 - 125 feet of fine white sands and clays characterized by mica and carbonized wood. The sands of the Magothy and Raritan formations are so interconnected that the two units act as a single aquifer and are so treated in this report. The overlying Pleistocene sands are part of the same hydrologic unit when they are in contact with the Magothy and Raritan. However, where the Pleistocene sediments are thick they can be distinguished from the Cretaceous sediments. North of the inner and stratigraphically lower margin of the Coastal Plain the Pleistocene sediments overlie crystaline rocks and are frequently thick enough to yield water. The Pleistocene sediments are therefore treated as a separate ground water unit. About twenty-four square miles of Mercer County have the Pleistocene sediments in contact with the underlying Magothy and Raritan formations.

From 70 to over 100 feet of black clays of the Merchantville and of the overlying Woodbury formations are found above the Magothy in a band from two and one-half to three miles wide, extending from Yardville and Crosswicks through Robbinsville and Windsor to and beyond Hightstown. Like the other Cretaceous formations, these clays are covered by Pleistocene sands which may be from 10 to 30 feet thick. Usually wells in this area are completed in the underlying Magothy-Raritan formation.

In extreme southern Mercer County the white to yellow quartz sands of the Englishtown formation lie above the Woodbury clays. Except for about one square mile south of Hightstown the dark gray sandy clays of the Marshalltown formation are found just south of Mercer County overlying the Englishtown sands. The Pleistocene cover becomes thin and patchy over the areas underlain by the Englishtown and Marshalltown formations which were not as deeply eroded in pre-Pleistocene times as the sandy Magothy and Raritan formations to the north.

A few domestic wells have been completed in the Englishtown formation in Mercer County. Even the sand lenses in the Merchantville formation have supplied water to a very few domestic wells. Most domestic wells and all industrial wells in and adjacent to the southern boundary of Mercer County are drilled to depths in excess of 150 feet in order to draw water from the sands of the Magothy or Raritan formations.

Although the Cretaceous formations of the Coastal Plain have been compared to the layers in a cake, the analogy should not be carried further because of the extreme variation of sediments within the water-bearing formations. The aquifers in the above-mentioned layer cake might be considered as "marble cake" in contrast to the solid cake layers of the clay formations.

The assumption of a uniform or average dip or increase in depth toward the ocean for the Coastal Plain formations, while useful, may be misleading when applied too strictly to predicting the depth at which water-bearing sands may be encountered. At three locations industrial wells less than one-quarter mile apart have been completed at depths in the 80 to 100 feet range and in the 250 or 300 feet range. Any attempt to correlate these depth ranges with specific horizons or members such as the Old Bridge or Farrington sands, as has been done in the Raritan formation in the type locality along Raritan Bay in Middlesex County, is without merit or basis in fact. The Farrington, Old Bridge, and other members of the Raritan cannot be identified in western Middlesex County nor in Mercer County. In Mercer County some of the most productive sands are found just above the "basement rock" in the stratigraphic position of Raritan Fire Clay further to the east.

Ground water may be secured in the Coastal Plain section of Mercer County from the Magothy-Raritan, from the Englishtown, and from the Pleistocene formations. Industrial wells most often rely on the Raritan formation, but in the northern part of the Coastal Plain this may have too much clay, be too thin, or be missing so that only Pleistocene or rock wells will be successful.

RARITAN FORMATION

The principal water-bearing sediments south of Trenton, Bakers Basin, Clarksville and Princeton Junction are the sands of the Raritan and Magothy formations. As used in this report, the term "Raritan" includes the overlying Magothy formation.

At times drillers and geologists have attempted to differentiate between the two formations. At times this can be done, but most of the time any such distinction between the two formations is debatable. In a general way if a driller is getting very fine white sand with "charcoal" fragments, he is in the Magothy. In general it would be, and in a number of cases it has been proved to be, a mistake to try to complete an industrial well in the Magothy. Aside from these two generalizations, the two formations are lithologically and hydrologically very similar.

Sections C-C, D-D, E-E and F-F of Plates II and III show the variation in sediments to be found in the Magothy-Raritan along lines nearly perpendicular to the strike of the formations. The section lines are shown on Plate I. Attention is called to the variation in thickness and position of the sands in the lower part of the formation and the rapidity with which the sands and clays lens in and out or interfinger as one moves down dip to the south. At first glance the most easterly section C-C′ would seem to have some similarity to the standard section of Middlesex County except for the addition of an extra sand member at the top of the section. Within three to five miles however, the seven formation members (Section E-E) have been reduced to two with some minor lenses of sand in the clay. Eight miles further to the west sands have replaced clays at the base of the section and there are four main members in the formation.

The full extent of the rapid change in the grain size and character of the Raritan formation can best be appreciated by an examination of Section G-G′-G″ on Plate III. The borings plotted on this section are thirteen of a series of borings made every thousand feet, extending from near Bordentown east to Raritan Bay along the line of a proposed trans-Jersey ship canal. All borings were made by the same company and logged and described by the same geologist. The rapid changes in the character of the sediments are typical of all parts of the section. Most of the bore holes penetrate five or six sedimentary units in the Raritan Formation; however, most of the section for hole B-119 is a single unit of very fine white sand. Hole B-113 is at the other extreme in that there are thirteen changes in the Cretaceous sediments penetrated. Conditions shown on this section help to explain why in the Raritan domestic wells less than 100 feet apart may have a difference of 50 feet in the depth at which the screen is set or why there is such a great variation in yield from nearby wells.

A study of the depth of 164 domestic and industrial wells completed in the Raritan formation indicates that the area underlain by the Raritan formation should be divided into three sub-areas. The first or most northerly sub-area extends southward from the northern or lower contact of the Raritan formation as shown on Plates I and IV and is outlined on Plate V. In this sub-area there are only a few shallow Raritan wells. The formation is either missing, too thin or a clay. North of Edinburgh and around Dutch Neck the basement rocks are within a hundred feet of the surface. The second sub-area starts with this line drawn through the most northerly Raritan wells (from one to four miles south of the Pennsylvania Railroad) and extends as far south as the northern Merchantville contact. Within the second sub-area Raritan wells are usually less than 100 feet deep. Wells over 200 feet deep begin to appear about a mile north of the northern Merchantville contact and are found in the third sub-area which extends to the southern border of Mercer County. Most wells which are approaching 300 feet in depth are south of Route 130.

Most Raritan wells in southern Mercer County are 250 feet or more in depth because of the overlying clay formation. Near Hightstown domestic Raritan wells a half mile apart on a line roughly parallel to the strike have been completed at 60 feet and at 317 feet. The latter well was drilled deeper to get a better quality water with less iron. Close to the Delaware River in the southern part of Trenton, wells for Trenton Brewing Company have been completed in the Raritan, which here fills a pre-Cretaceous Delaware River Valley, at several depths from 80 feet to and including 280 feet. Domestic wells can at times be completed near the top of the Magothy formation, but industrial wells are usually completed in, and give more water from, the lower sands of the Raritan. In southern Mercer County there are many areas where the Raritan formation is thick enough to have good water-bearing sands for large yield industrial wells at two or more horizons. These lower horizons are, at present, not always needed or used for industrial development.

It is nearly certain that an adequate domestic well can be constructed in the Raritan once it has attained a stratigraphic thickness of about 100 feet. Industrial wells are more successful where the formation is nearer 200 feet thick. Only one-sixth of the industrial wells are 100 feet or less in depth.

With respect to yield, nearly one-third of the industrial wells are reported as giving in excess of 400 gpm when first tested and another quarter of the industrial wells give between 200 gpm and 400 gpm. If started with a sufficiently large diameter, ten inches or more, a properly constructed industrial well may reasonably be expected to give at least 500 gpm. Efforts, however, to increase the first large yield by sustained development and surging have resulted in the complete collapse of at least two industrial wells. Large yields may be obtained by using long screens in thick sections of fine-grained sands or by the more usual construction which uses a shorter screen in a coarse sand or gravel sought and found at a greater depth. If the best well is to be constructed for the least money, the rapid variation in the sedimentary character of the Raritan formation will require the driller and owner to keep an open mind and a flexible set of specifications until the well has been completed.

Merchantville Clay

The Merchantville is a black glauconitic micaceous clay from 50 to 60 feet thick which rests disconformably on the Magothy. Three domestic wells, East Windsor #22 and two wells outside Mercer County (Raritan #10 and #15), are reported as having been completed in this formation, probably at or near its lower contact.

Woodbury Clay

The Woodbury clay is also black and about 50 feet thick, but it is a non-glauconitic clay. It is conformable with the Merchantville below and the Englishtown above. No wells are reported as drawing from this formation.

Englishtown Formation

Along the southern border of Mercer County the white-to-yellow quartz sands of the Englishtown formation underlie patches of Pleistocene sands and gravels or are exposed at the surface. The formation has a thickness of about 120 feet in Mercer County. East of the extreme southern tip of the county domestic wells with yields from 5 to 60 gpm have been completed in the Englishtown. Elsewhere industrial wells give up to 250 gpm. The lack of industrial wells in the area covered in this report reflects the rural land use rather than an inability of the formation to supply water.

Marshalltown Formation

The Englishtown sands are capped by the dark sandy clays of the Marshalltown formation which is not known to supply water to any wells. Less than a square mile of the Marshalltown formation is found in Mercer County; most of the formation is found to the south.

RARITAN FORMATION

DOMESTIC WELLS — *YIELD IN GALLONS PER MINUTE*

Township	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
Hamilton	44	47	7	15	15
West Windsor	15	50	5	19	15
Washington	24	55	7	24	23
East Windsor	24	60	3	19	15
Kmr south of Mercer County	13	80	7½	32	30
Englishtown formation	15	60	5	19	12

NOTE: No domestic wells in Trenton.

INDUSTRIAL WELLS — *YIELD IN GALLONS PER MINUTE*

Township	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
Trenton	11	1,040	60	383	350
Hamilton	27	700	35	246	200
West Windsor	2	520	335	..	..
Washington	3	260	40 (60)	..	..
East Windsor	14	1,500	55	470	363
Kmr south of Mercer County	12	580	40	361	503

NOTE: No industrial wells in Englishtown Formation.

RARITAN FORMATION

DOMESTIC WELLS

Township	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
		DEPTH IN FEET BELOW SURFACE			
Hamilton	44	317 (304)	55	115	100
West Windsor	15	205	55	103	92
Washington	24	248*	82	163	129
East Windsor	24	315	70	175	181
Kmr south of Mercer County	13	456	76	230	200
Englishtown formation	15	212	35	118	134

NOTE: No domestic wells in Trenton.
* Does not include Washington #31, a test well driven to 365 feet and abandoned.

INDUSTRIAL WELLS

Township	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
		DEPTH IN FEET BELOW SURFACE			
Trenton	11	280	80	150	117
Hamilton	27	334	67	194	220
West Windsor	2	100	90	..	..
Washington	3	310	218 (230)	..	..
East Windsor	14	280	137	213	216
Kmr south of Mercer County	12	537	73	268	358

NOTE: No industrial wells in Englishtown Formation.

PLEISTOCENE DEPOSITS

At least forty-seven wells in Mercer County draw from Pleistocene sands and gravels. Nearly half of these wells are in or near Trenton and have been completed in the "Trenton gravels" or, as it is shown on the State Geologic Map, the "stratified drift." Most of the remaining wells are found to the east around Clarksville and Dutch Neck with a scattering of wells in the Coastal Plain from White Horse to Hightstown. These wells probably draw water from the Pennsauken formation, but one or two wells may draw from deposits mapped as belonging to the Cape May formation.

Pleistocene deposits are shown on the geologic map as covering much of the surfaces of Mercer County to the south of West Trenton, Ewingville, Lawrenceville and Princeton. More recent work by Tedrow and MacClintock indicates that Pleistocene loess deposits cover much of the area underlain by Triassic rocks south of Titusville, Glen Moore, and Hopewell to the northern border of the above-mentioned deposits of Pennsauken gravel. Thus only those parts of Mercer County found above 250 feet in elevation or on the lower slopes of the most recently eroded valleys would seem to be free of Pleistocene deposits. Usually the loess deposits are only two or three feet thick and usually the older water-laid Pleistocene deposits are only ten to fifteen feet thick. Loess deposits may reach a thickness of ten feet while the Pennsauken is known to be over one hundred feet thick in some areas in southern Mercer County.

Most of the descriptions of the Pleistocene deposits are found either in "Glacial Geology," Volume V, or "Surface Deposits," Volume VIII of the Reports of the State Geologist of 1902 and 1916 by Salisbury and others. The present-day concepts of Pleistocene stratigraphy were not fully developed at the time of publication of either of the above works. While multiple glaciations were recognized at the time (1902) of the publication of "Glacial Deposits," Volume V, the Iowan (now considered as a stage of the Wisconsin) was believed to be a pre-Wisconsin glaciation occurring before the Wisconsin. By 1916 the situation was somewhat improved. The three formations, Bridgeton, Pennsauken, and Cape May, into which the whole complex of "yellow gravels" or the "Columbia formation" was divided in "Surface Deposits," Volume VIII, were considered to be fluvial deposits formed during periods of higher sea levels in valleys eroded during the previous time of lower sea levels. In short, the deposits were considered to have formed during the interglacial stages. Sands and gravels most obviously related to the time of the Wisconsin maximum were called "unclassified," "the Trenton gravels" or in later publications "stratified drift." Separation of the several Pleistocene formations was based on lithology, degree of weathering, topographic expression and elevation, or a combination of all of these characteristics. The great difficulty with this method is that in some areas and in some lithologies it is almost impossible to distinguish one or another of the "formations." With our present-day knowledge of Pleistocene events, it would seem that each of the "formations," while they may be primarily interglacial deposits, must also in part be related to the next glacial stage. The problems of correlation and origin have not yet been resolved on a state-wide basis, nor even on a county basis; so it would seem to be more practical, at least from the ground water point of view, to refer to the whole series as "yellow gravels" or "Pleistocene deposits."

From a theoretical point of view some of these deposits, because of their origin or the nature of their sediments, should not be favorable for the occurrence of ground water while others would be most desirable. Thus well sorted gravels deposited by rapidly flowing streams would be much better aquifers than deposits of silt and clay laid down in a sluggish estuary. If such a distinction can be made in a local area as the result of abundant exposures and well logs, it may make considerable difference in the way in which a water development program is carried out in a restricted area. In general, however, this cannot be done.

The Bridgeton so resembles the Pennsauken that they can be treated as a single hydrologic unit, and are considered by some authorities as a single formation. In Mercer County the Cape May formation is supposedly found between the Pennsauken and the "Trenton gravels." Its occurrence, however, as compared to the older Pennsauken and younger "Trenton gravels" or "stratified drift," is so restricted in area and so difficult to determine from well samples that the Cape May formation also can be ignored and treated as a part of the Pennsauken. As indicated earlier, almost as many wells have been completed in the "Trenton gravels" as in the Pennsauken so that the two formations have very similar ground water and geologic characteristics.

Whatever the ultimate division and classification of the various Pleistocene deposits or "yellow gravels" in Mercer County in so far as their origin and classification is concerned, they may be divided into four types of Pleistocene materials: (1) loess; (2) poorly sorted, brown, reddish-brown or almost pink sands, silts, clays and gravel with large boulders; (3) well sorted yellow coarse gravels and sands; and (4) mixed yellow to brown gravels and sands of considerable thickness.

The yellow loess deposits, described by Tedrow and MacClintock, cover large areas along the ridge tops east of the Delaware River from Jacobs Creek northward to Titusville and as far east as Lawrenceville and southwestern Montgomery Township in Somerset County. No wells are completed in this material, but its presence on the surface permits a much more rapid percolation of rainfall than that permitted by the heavy clay soils normally developed on the Brunswick shale, Lockatong argillite, or diabase. It would seem likely that domestic wells drilled in areas with a thick loess cover would have a slightly better yield and higher static level than wells in similar Triassic formations without this cover. No effort was made to evaluate this possible effect.

Poorly sorted brown, reddish-brown, or almost pink sands, silts, clays, and gravels with large boulders are found south of the loess deposits chiefly in Ewing Township, but also in western Lawrence Township and the northern parts of Trenton. Usually shown as belonging to the Pennsauken formation, this group of Pleistocene deposits includes some "stratified drift" or "Trenton gravels," some terrace deposits in Hopewell Township, and some small isolated thin coverings of gravel on hilltops in Princeton Township.

Gravel terraces rise some thirty feet above the normal level of the Delaware River on the New Jersey side in the vicinity of Titusville. A similar terrace starting south of Scudders Falls extends through Wilburtha into Trenton and as far south as the State House in Trenton. Wells for homes built on these stream terraces are normally completed in the underlying Triassic rocks. Up river on similar terraces, industrial wells of the "caisson" type have provided large amounts of water which is a little cleaner than water taken directly from the Delaware River. Ground water in these terrace deposits responds rapidly to changes in river level. Where bedrock is above river level, the overlying gravels are usually dry and thus useless as a reliable source of ground water.

North of Titusville and north of Jacobs Creek gravel terraces whose tops are some sixty feet above the Delaware River have been mapped as Pennsauken deposits. Neither these terraces nor gravels, also mapped as Pennsauken, found along ridge tops in eastern Lawrence Township and western Princeton Township are thick enough to affect the general ground water conditions in their vicinity.

Most of the poorly sorted brown to pink gravels are found in Ewing Township south of West Trenton and Ewingville. These "Pennsauken gravels," as originally mapped, included only the materials found above elevation eighty. Gravels in the valley of the Shabakunk and its tributaries were apparently considered as Recent deposits. However, examination of excavations in both areas in recent years suggest that there is no significant difference between the two deposits. The length of well casing required in several "Pennsauken" areas also suggests that the present drainage is still above the bottom of the gravels and thus suggests that the gravel sheet is continuous across the minor streams in Ewing Township.

These "Pennsauken deposits" underlie a hummocky terrace containing several small lakes, ponds, and marshy areas. Several of the old farmsteads have large spring houses and hand-dug shallow wells. A few also have farm ponds. Although there seem to be no records of drilled wells completed in this material, a study of the wells in Ewing Township indicates that all but three out of twenty-nine domestic wells in argillite, which underlies the higher ground in northern Ewing Township, have casings less than thirty feet long. However, two-thirds of the sandstone wells, nearly all of which are found in the area covered by thick deposits of these brown-to-pink "Pennsauken" gravels have casings from 31 to 110 feet in length. Of these, eleven wells have casings from 40 to 49 feet long and eight wells have casings in excess of fifty feet. The pockets of boulders described in the early geologic reports as a characteristic feature of the Pennsauken Formation made it difficult to drive casing to bedrock at Fernwood (New Jersey Highway Department) in Western Ewing Township. Other boulder pockets may have been encountered by drillers and excavations frequently turn up boulders. Usually less than a foot long in any direction some boulders have been found with a volume of several cubic feet.

These thick accumulations of brown to pink poorly sorted gravels, sands, silts, and clays with the occasional large boulders probably store a considerable amount of ground water above the bedrock and should improve the potential yield of wells completed in the area of their occurrence. A comparison between wells completed in the Stockton sandstone in Ewing Township shows that they are slightly better than the Stockton sandstone wells in Hopewell Township. A comparison with the sandstone wells in Lawrence, Princeton, and West Windsor Townships is not valid because most of these wells are found in areas where the sandstone is capped by thick deposits of the "Trenton gravels."

A veneer of well sorted yellow gravels and sands covers an extensive area from the junction of Stoney Brook and the Millstone River southwestward along the valley of Stoney Brook and the Assunpink to Trenton. The upper surface of this formation is quite flat, but the gravels were deposited on a highly irregular surface. Perhaps most often twenty-to-thirty-feet-thick bedrock may be less than ten feet below the surface, or the gravels may fill deep channels in the bedrock. Variously described as "Trenton gravels," "stratified drift" or "unclassified deposits", the gravels seem to be related to the last or Wisconsin Ice and represent the valley train of a river carrying melt water from the ice front which then extended from the Plainfield area north and northwestward until it crossed the upper reaches of the Raritan River. For a time a stream of melt water ran southwestward from Bound Brook through the Rocky Hill Gap to the Delaware at Trenton.

This reversal of the present-day drainage happened at least once before because the "Trenton gravels" along the southern margin are found resting on older Pennsauken and/or Cape May gravels which have filled other deeper preglacial valleys to the south. In the original mapping of the "Trenton gravels" it was also suggested that the valley extending westward from Princeton Junction followed by Little Bear Brook and including the area of Upper Bear Swamp might also have been filled by Trenton gravels. However, the problem of whether the lowest parts of the present valleys were actually filled with Trenton, Cape May, or Pennsauken gravels was left unresolved. One domestic Pleistocene well near Princeton Junction has been completed in the above-mentioned southerly channel. Seven domestic wells and nineteen industrial wells completed or attempted in the "Trenton gravels" are located in Trenton or immediately adjacent parts of Hamilton Township. In addition to the twenty-seven Pleistocene wells in Mercer County which were completed in the "Trenton gravels," another fourteen industrial wells and several domestic wells were completed in the underlying rock. In areas where the "Trenton gravels" can, and probably do, provide ground water storage, wells in bedrock can sustain higher than normal yields. The Princeton Water Company wells along the banks of Lake Carnegie and the Millstone River are excellent examples of rock wells whose large yields are both maintained and polluted by water moving freely through thick overlying gravels.

West of Bakersville the underlying Precambrian bedrock is unfavorable for the development of industrial water wells, and several industries have had to rely on shallow Pleistocene wells. In the Trenton area the Assunpink effectively recharges these gravels. However, the gravels overlying the higher bedrock elevations (southern Trenton) drain rapidly. Trenton wells #17 and #21 and Hamilton #85 were abandoned because the gravels gave so little water or resulted in dry holes. Trenton wells #5, #6, and #7, drilled for Roebling, were dry in the gravels and were not continued far enough in the underlying rock to get any water. By definition, the Roebling wells are classed as Precambrian wells, since they got no water in either formation but were finished in Precambrian rock. A number of gravel wells in the Trenton area were abandoned soon after completion because of pollution.

In planning to utilize the "Trenton gravels," therefore, a great deal of attention must be paid to the thickness of the gravel. The elevation and location of the well with respect to surface streams and lakes and the elevation of the underlying bedrock will determine whether water can be secured at all and the quantity which may be expected. Consideration of sources of pollution is essential because of the free movement of water in the gravels. The character of the underlying bedrock will determine whether the gravels are the only good source of water or whether they can be used for storage above the rock well.

The mixed yellow to brown gravels and sands of considerable thickness, which are described as the Pennsauken formation, also include the sediments assigned to the Cape May formation and provide water to domestic and industrial wells in Hamilton, Washington, East Windsor, and West Windsor Townships. The Pennsauken and Cape May formations are found south of the Trenton gravels in Hamilton and West Windsor Townships. As indicated above, Pennsauken gravels have also been mapped north of the Trenton gravels. The ridge from Clarksville to Penns Neck is capped by a thin veneer of Pennsauken which may be separated from the main mass of the formation to the south by a deposit of Trenton gravels in the above-mentioned valley of Little Bear Brook and Upper Bear Swamp.

Some gravels in the general area, south of the Trenton gravels, have been mapped as belonging to the Cape May formation. Both formations filled in the pre-Pleistocene valleys and buried the topography beneath an extensive sheet of sediments. Erosion removed some of the Pennsauken formation before later Pleistocene events deposited the Cape May formation. Erosion again partially removed the earlier Pleistocene formations before deposition of the "Trenton gravels."

This sequence of events and the distinction between Cape May and Pennsauken is significant from the ground water point of view only if the remnants of the Cape May formation are predominately estuarian. The low topography and presence of swamps in many areas mapped as underlain by Cape May gravels suggest that this may be the case. West Windsor well #93 gave 100 gpm from 41 feet and was completed in Pennsauken gravels. West Windsor well #2 located on lower ground to the east and in an area shown on some maps as underlain by Cape May formation was abandoned without a test because of the lack of water although the gravels fraction in wells #93 and #2 seemed identical in appearance. The Cape May formation in general is described as finer grained and less weathered than the Pennsauken formation.

The Pennsauken deposits vary from coarse, well sorted gravels to well sorted sands to sands and gravels with a high porosity to local areas of gravel so choked with silt and/or clay as to be almost impermeable. In general, however, the formation is about 90% sand with cut-and-fill stratification and rapid abrupt changes in grain size and is extremely permeable and porous. In the vicinity of Clarksville and Penns Neck the Pennsauken formation is generally only a few tens of feet in thickness. To the south where the Pennsauken overlies the Raritan formation and to the east along the county border where the sediments fill pre-Pleistocene valleys the formation may exceed 100 feet in thickness. Section CC', Plate II shows the great thickness (125 feet West Windsor well #32) in the area near Penns Neck and Hightstown. Sections DD' and EE', Plate II and FF' and GG', Plate III shows the extreme variation in thickness of the Pleistocene cover in southern Mercer County.

In the vicinity of Edinburg the Precambrian bedrock is very close to the surface and probably is covered only with Pleistocene sediments. For about a mile south of the Pennsylvania Railroad the lower or northern contact of the Raritan, the Raritan formation is predominately clay and silt. In this area, shown on Plate V as an area of poor ground water supply, south of the area of Precambrian and Hardyston quartzite in central Mercer County, the Pennsauken formation provides the only potential water supply for domestic, industrial, and irrigation wells. Usually adequate for domestic wells throughout the above-mentioned area the Pennsauken does not seem to be thick enough to support industrial or irrigation wells requiring large yields. West Windsor #94 and #95, industrial wells in this area, give 70 gpm and 190 gpm as compared to industrial wells #86 and #91 completed in thicker Pleistocene to the south and east, which give 340 gpm and 240 gpm respectively.

In the area between Princeton Junction and Hightstown, the Pennsauken fills a pre-Pleistocene river valley and is an important source of ground water. Elsewhere it may be thick and underlain by sandy parts of the Raritan formation so that the two formations can be treated as a single unit.

Lenses containing abundant clay and silt may cause poor surface drainage, perched water tables, and poor yields from shallow or small diameter wells completed in the Pennsauken formation. Such areas are usually at most an acre or two in extent and the lenses are only a few feet think.

In the table of Pleistocene well yields and depths which follows, the Industrial wells in Trenton and Hamilton Township have been completed in the "Trenton gravels." Nearly all of the remaining industrial wells and all of the domestic wells were completed in the Pennsauken formation (or the Cape May formation which is here included with the Pennsauken).

PLEISTOCENE WELLS IN MERCER COUNTY

There are no domestic Pleistocene wells in Trenton, no industrial Pleistocene wells in Washington Township and only one industrial Pleistocene well (60 gpm from 73 feet) in East Windsor Township.

DOMESTIC WELLS

Township	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
		YIELD IN GALLONS PER MINUTE			
West Windsor	6*	80	10	29*	15
East Windsor	5	15	7	12	12
Washington	2	30	12	..	..
Hamilton	7	15	3	9	10
		DEPTH IN FEET BELOW SURFACE			
West Windsor	6	125	20	63	59
East Windsor	5	85	38	68	73
Washington	2	108	67	..	..
Hamilton	7	62	17	50	55

* Average of six wells is 29 gpm, excluding 80 gpm well, average of five is 19 gpm.

INDUSTRIAL WELLS

Township	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
		YIELD IN GALLONS PER MINUTE			
Trenton	8	200	5	62	50
Hamilton	12	228	2	117	132
West Windsor	7	340	50	162	145
		DEPTH IN FEET BELOW SURFACE			
Trenton	8	135	26	84	89
Hamilton	12	61	25	42	42
West Windsor	8*	113	27	67	78

* Includes one well that was never tested.

LOT SIZE AS RELATED TO WELLS

The most troublesome problem for realtors, planners, and local governing officials who must approve sub-division plans and industrial sites is the determination of lot sizes where individual wells and septic tanks are to provide water and dispose of sewage. A growing awareness of pollution problems and of inadequate or competing water supplies, has focused attention on the need for some kind of guide-lines as to lot size, or well spacing, or other methods for protecting the ground water resource. It was overdrawn at Penns Neck in West Windsor Township during World War I. It should be protected from pollution and development beyond its capacity as has occurred at several places in the northern townships.

Precipitation provides a little more than 2,000,000 gallons per day per square mile in Mercer County. Usually at least half of this is lost to evaporation and transpiration. The remaining 1,000,000 gallons per day per square mile goes into runoff and recharge.

The northern part of Mercer County which is underlain by shale, sandstone, argillite, and diabase has a much higher runoff component than the southern part of the county underlain by the unconsolidated sands, gravels, and clays of the Coastal Plain. Streams draining the Coastal Plain area have a much more uniform flow and a higher dry weather flow than streams which drain the rock country. This indicates that the recharge component is substantially greater in the Coastal Plain than in the northern "rock country" of Mercer County.

Several approaches may be made to determine a safe sustained yield for wells in the two different areas of Mercer County. These efforts to evaluate the total actual or potential recharge component indicate that the sediments of the Coastal Plain have a safe sustained yield of about 1,000,000 gallons per day per square mile. The Brunswick shale areas of northern New Jersey and southern Mercer County have a safe sustained yield of about 500,000 gallons per day per square mile. It is at once obvious that the value for the safe sustained yield of the relatively flat to rolling shale lowlands of the shale areas is greater than that for areas of greater slope, thinner soil, and less frequent and less open fractures found in the harder rocks which underlie the ridges.

The geologic history of northern Mercer County and central New Jersey has been such that soil type and thickness, land use, topographic expression, slope, and relative abundance and openness of fractures is very similar for areas with the same type of bedrock. The variation in climate is not such that it will cause any appreciable difference between rock types in soil, slope, or amount of runoff. Slope, soil type, and land use provide factors usable in determining runoff and even percolation rates so that much can be determined about runoff and the potential availability of the surface water supplies. The ground water potential is a more difficult problem because in rock formations wells must intersect open water-bearing fractures. If a lot of fractures are cut by a lot of wells, the wells give a lot of water. If only a few fractures are cut by a lot of wells, then most of the wells are poor or inadequate and there is less ground water available. The fracture systems are not always uniform nor interconnected so that each individual well becomes a separate problem. A set of values developed for one well are not readily comparable or related to the capacity of the next well because the fracture system may change considerably in a few tens of feet.

The maximum, minimum, average, median, and mean values of depth and yield for a large number of wells completed in one rock type should, if compared to a similar large number of wells in another type of rock, give some indication of the relative abundance and openness of fractures. To put it in a different way, if the safe sustained yield of one rock type is known, then by comparing a large sample of wells in a second rock type an approximate safe sustained yield can be computed for the second rock type. If 225 wells drilled in areas underlain by argillite are compared to 215 wells drilled in an area underlain by Brunswick shale, as has been done in the discussion of argillite, the comparison which indicates that the maximum yield, average yield, median yield, and relative distribution of the various amounts of water secured in the argillite wells are each only about half as good as the wells underlain by shale, then it logically follows that only half as much of the total rainfall is going into the ground in the argillite area as is going into the ground in the shale area. The comparative size of the two areas, since they are not greatly different is irrelevant. The wells are both scattered and grouped in both formations, giving a truly random sample. The random sample can then be applied to a specific equal area to determine the probabilities of securing various amounts of water.

If a given quantity of water is required, there would of necessity, then, have to be twice as many wells and twice as big an area from which they could draw water in order to have an average chance of securing the same amount of water in an area underlain by argillite as would be required in an area underlain by shale. However, in our comparison we must also consider the probabilities of securing any particular amount of water and the probabilities of securing no water or minimum yields. A study of these conditions would indicate that in an argillite area our chance is not half as good, but something less than half as good, as it is in an equivalent sized area underlain by shale. There are in nature, of course, many other variables, particularly in small areas such as a fault zone, which might radically change the expected figures for any single individual well. However, the more wells that are drilled, the more they will approach the average conditions. In this study a sampling of 250 wells in Hopewell Township gave the same results as a sampling of 750 wells.

As indicated above for the areas of the Triassic shale of the Brunswick formation and the sandstone of the Stockton formation in New Jersey, estimates and studies of the percent of rainfall which is available from the ground water reservoir can be attempted from a number of different starting points, and all will ultimately end up with a value close to 25% of the average rainfall being available from ground water sources. This amounts to something slightly more than 500,000 gallons per day per square mile as a safe sustained yield. If, then, 600,000 gallons per day per square mile were removed from any one square mile area underlain by these Triassic formations every day, year in and year out, the ground water would gradually be removed from the area since the average amount of rainfall could not replace, by natural processes, the full amount of water removed from the fractures and openings in the rocks which are tapped by the wells. If no water were removed from adjacent areas, lateral replenishment of ground water might maintain the supply. This, however, would then be equivalent to drawing from a larger area.

If an attempt is made to use ground water availability as one criteria for the determination of minimum lot sizes for properties with individual wells and individual septic tanks, the ground water yields must be related to the average per capita consumption and average family size to determine how large an area is required to supply the needs of each household.

Statewide figures from water companies indicate that the per capita consumption per day ranges somewhere between 25 and 250 gallons per person. The larger figures are from water companies which have a large amount of industrial services. The smaller figures are from water companies where many households within the franchised area are drawing water from individual wells. A generally accepted figure at the present time is about one hundred gallons per person per day. It is believed this figure will increase over the years. If we assume an average per capita consumption of one hundred gallons per person per day and an average suburban family of five persons, we find an average family uses about 500 gallons per day. This figure of 500 gallons per day per household is more convenient than accurate, but it is fully satisfactory for the estimates being given here because of the two compensating variables, family size and water use, which tend to work in opposite directions to produce the same average figures. A family of five using 100 gallons per person per day uses as much as the statistical average suburban family of 3.9 or 4.3 persons using 130 or 115 gallons per person per day. Obviously, small water use of the retired couple is offset by the large water use of the young family with five small children and Aunt Matilda.

Applying this demand of 500 gallons per day per household to an area underlain by red shale, we find that if there were 1,000 individual households drawing from individual wells in a one-square-mile area, they would have a daily water requirement which would equal the 500,000 gallons per day per square mile safe sustained yield of the shale. One thousand families on 640 acres would give a minimum average lot size of two-thirds of an acre per house. Access roads would reduce the actual lot size to slightly below this average size.

It should be clearly understood that this water would not actually leave the one-square-mile area since it would be dumped into the household septic tank system where it would probably again find its way underground. However, if this ground water effluent is not continually diluted by rainfall or some other new water supply, it will very shortly become contaminated. The shales and sandstone in themselves probably do not aid in filtering or otherwise purifying septic tank effluent. Most of what purification is done in nature occurs as oxidation above the weathered rock zone or is accomplished by plants, by the soil, and by the action of bacteria in the septic tank system.

As previously explained, argillite has something less than one-half of the ground water potential of a shale area. If we assume that argillite is only one-third as good as shale, we could then take the minimum lot size for shale (two-thirds acre), multiply it by three, and arrive at the minimum lot size of two acres for areas underlain by argillite. Similarly, if it is only one-fourth as good as shale, the minimum lot size would be two and one-half acres. If a water supply system and sewerage system are provided in an argillite area, the minimum lot size could be substantially reduced.

It is up to each developer and each group of citizens in an affected area or in a municipality to determine whether they should have a water supply system, a sewerage system, or both; or require a minimum lot size sufficiently large to permit the construction of individual wells and septic tanks.

It should be clearly understood that the inadequacies of the ground water supply would not appear in any area under development until most of the area has been taken up and most of the wells have been drilled. Until the full development has taken place, the net effect is the same as though the wells were drawing from the larger lot sizes. It would also hold to a lesser extent that adjacent areas of no or low water use would in effect also increase the lot size. A comparison of the county summaries for argillite and diabase show that the two formations are about equally bad.

For those who may question the validity of a two-acre minimum lot size for argillite areas, we can only reply that in a few developments which have been brought to our attention where the underlying rock is either argillite or its ground water equal, diabase, we have had contamination cases, complaints of inadequate wells, and other problems resulting from a water supply deficiency whenever the lot size averaged less than two acres. The well records from one housing development in Hopewell Township, as indicated in this report, suggest that the minimum lot size of two-thirds acres in shale areas may be too small to support the needs of individual household wells.

The lot sizes for industry or the spacing of industrial wells is a more difficult problem. A need for 500,000 gallons per day would seem to require a square mile of plant site. However, adjacent land use may not require large amounts of water or adjacent properties may be served by a water system. Such factors should be considered and each large industrial water requirement should probably be treated as an individual case. When the industrial requirement has been ignored, expensive solutions may be required at a later date. Since a 500,000-gallon-per-day requirement is equal to almost 350 gpm on a 24-hour basis, a rough rule of thumb planning figure of one acre of plant site for each one gpm required on a twenty-four hour basis is suggested. This does not meet the full requirement as indicated above—only half of it; but industrial needs are often increased by fire protection requirements which are seldom used or by cooling water which may be returned to the ground. Even the suggested figure is considered too high by most industrial realtors, but it will provide a basis for negotiation.

A minimum lot size for the coastal plain areas is even more difficult to compute. At first glance it would seem that one-third-acre lots would be adequate if the wells in the coastal plain sediments are twice as good as wells in shale, which industrial wells are, but such a lot size is not big enough to allow the wells to be separated from septic tanks and sewerage lines the distance required by health laws. The comparison of the domestic wells shows that the yields are nearly the same for shale or sandstone and the Raritan formation. This is probably due to construction of wells capable of meeting the household need rather than a lack of water available to wells in the formation. The biggest problem in the estimates of ground water potential in the coastal plain is caused by the fact that the area of a formation which can be tapped by wells is much larger than the area of outcrop of the formation. Each square mile of outcrop is thus supplying a much larger use area. The control over the use of the ground water in a coastal plain formation does not rest solely with the local government unit that controls the outcrop area.

CONCLUSIONS

There is an abundance of ground water in many parts of Mercer County which will enable wells to meet most water needs for many years to come. Some areas, however, even at the present time, are problem areas with meager supplies and many will always remain so if dependence for water is placed on wells.

The ground water resource is not always available in the areas of greatest need, nor can it be supplemented in some areas with the surface water supplies available from the Delaware River or the Delaware and Raritan Canal. The Delaware River and the canal at present provide water to the larger portion of the population and to water-using industry of Mercer County.

Domestic wells are usually adequate from moderate depths in the areas of Brunswick shale and Stockton sandstone. From one-half to one-third of the wells completed in argillite or diabase are inadequate. If the individual homeowner is willing to spend the money to drill a deep enough well, or wells, and will maintain a large enough house lot, an adequate potable domestic water supply can be obtained from the argillite and diabase. Domestic wells are not always successfully completed in the Precambrian or pre-Triassic crystalline rocks although almost all wells will give some water. Raritan wells are adequate, but in some instances have had to be deepened to get good quality water. The potential for hand dug or drive point domestic wells completed in the Pleistocene and/or the near surface Raritan sands has been utilized in only a few areas.

Industrial zoning now in effect in the county will limit industrial development to three general areas: (1) in southern Mercer County along and near Route #130 and the Bordentown line of the Pennsylvania Railroad; (2) in central Mercer County along U. S. Route #1 and the Pennsylvania mainline; and (3) in the northern part of the county along the Reading Railroad and Route #69 and county route #518.

Deep wells to the lower Raritan in the southern industrial zone, if properly constructed, can be expected to yield 500 gpm or more from depths between 200 feet and 350 feet.

Ground water resources in the central industrial zone are moderate in some selected areas and negligible in some of the western parts of the area. The Delaware and Raritan Canal is within or close enough to the Central industrial zone to serve as a source of water.

The northern industrial zone of Mercer County has several areas with no ground water potential; others with only a moderate potential, and lacks any nearby large surface water supplies because much of the area is along the high ground forming the drainage divide between the Delaware and the Raritan Rivers.

Moderate industrial or public water supplies can be developed in areas underlain by the Brunswick shale or the Stockton sandstone by either careful attention to the location of minor geologic structures which may substantially increase the yield of a well or by drilling multiple wells to depths between 200 feet and 400 feet on spacings of at least 200 feet in the hopes of securing a total yield which will be equivalent to an average yield in excess of 100 gpm from each well.

Industrial or large-capacity public supply wells should not be attempted in areas underlain by argillite or basalt. The pre-Triassic crystalline rocks would also seem inadequate for wells requiring large amounts of water.

Housing developments relying on individual wells and septic tanks with two-thirds of an acre minimum lot sizes in areas underlain by shale and sandstone and two acres minimum lot sizes in areas underlain by argillite and diabase can probably secure adequate potable domestic water supplies without the attendant danger of contamination. Public water supply and sewage systems would seem to be desirable if lot sizes are planned below the above minimum values.

The determination of lot sizes for industrial plants depends on many factors of land use and neighboring water requirements and should be considered on an individual basis. A rough figure of one acre for each one gallon per minute of water required on a twenty-four hour basis would seem to be a reasonable starting estimate for lot size, which would be modified up or down as the investigation is made.

Minimum domestic lot sizes in the Coastal Plain Formation would probably be about two-thirds of an acre. Local permeability problems might make a larger size desirable.

Industrial lot size and spacing of wells should be determined within the framework of the relationship of the area within which wells are completed to the Raritan as compared to the outcrop and recharge area. All of the latter is found in Mercer County while the former area extends a considerable distance to the south of the county boundary.

RECOMMENDATIONS

1 Residential areas where reliance is placed on individual household wells and septic tanks should be zoned in accordance with the underlying rock to a minimum lot size as follows:

Pre-Triassic Crystalline	1 Acre
Stockton Sandstone	⅔ Acre
Argillite	2 Acres
Brunswick Shale	⅔ - 1 Acre
Raritan and Coastal Plain	⅔ Acre

If public water supply and sewerage systems are installed, the minimum lot size can be smaller.

2 Planning for the integrated development of existing and future public water supply systems in the areas of poor ground water availability should be instituted and made a continuing program. Such an approach is particularly important in the Princeton-West Windsor Township area.

3 Programs leading to greater availability of surface water supplies in the central and northern industrial zones should be inaugurated. Proposals in the TAMS Report and those supported by Oldis and others in the Stony Brook and Jacobs Creek Watershed could serve as a starting point for such studies. Mercer and Somerset Counties, Hopewell and Montgomery Townships and Pennington and Hopewell Boroughs can achieve only very limited industrial development with the existing availability of water in the northern industrial zone. The proposed programs could be linked to open space and recreation for the general benefit of the entire area.

Symbols Used in Township Well Tabulations

Boroughs, towns or other local government units with a small area are included in surrounding or adjacent township units.

Well Number	Well number as indicated on well location map. Each township has a separate series of numbers.
Casing Diameter (inches)	Final diameter of the well or diameter of screen. Six inch well unless indicated otherwise.
GPM	Yield in gallons per minute as reported by driller.
Well Depth (feet)	Depth of well in feet from surface as reported by driller.
Fm	Geologic formation from which water is secured. Fm (P) well pumping from fm indicated. Fm (B) well bottoms in fm indicated. See geologic map for formation symbols. PC = pre-Cambrian Pleistocene is undifferentiated in tables.
Casing Length (feet)	Length of casing used in well. This usually indicates the top of sound rock or top of screen.
Static Water Level (feet)	Static level of water in well as feet below the surface as reported by driller.
Owner	Owner as given on well permit at time well was drilled. Where a change in ownership is known to the Bureau, the newer name is used.
Year Drilled	Year well was drilled. '00 - '63 = 1900 to 1963; '80 - '99 = 1880 to 1899.
Use	Type of well; I = industrial. Otherwise well is classed as a domestic well.
Water Level/ Hours Pumped	Pumping level and duration in hours as given by driller on well report form. If hours are not specified, assume a two hour or less bailer test.
	Any pertinent remarks or unusual conditions are given as a second line.
. . . .	For value indicates no figure is available from well record information.

The townships are not placed in alphabetical order, because it was felt that the report could most conveniently be used if adjacent townships with the same geology were described in the same section of the report. Thus, Hamilton, Washington, and East Windsor, which are predominantly Coastal Plain, are described immediately after the city of Trenton. West Windsor, which has more Coastal Plain and some Triassic, is next described. Princeton, Lawrenceville, and Ewing, which have predominantly Triassic shales and sandstones, are described next. Hopewell, the largest township and the one with the most complex geology, is described last.

State of New Jersey

Department of Conservation and Economic Development
ROBERT A. ROE, *Commissioner*

Division of Resource Development
KENNETH H. CREVELING, *Director*

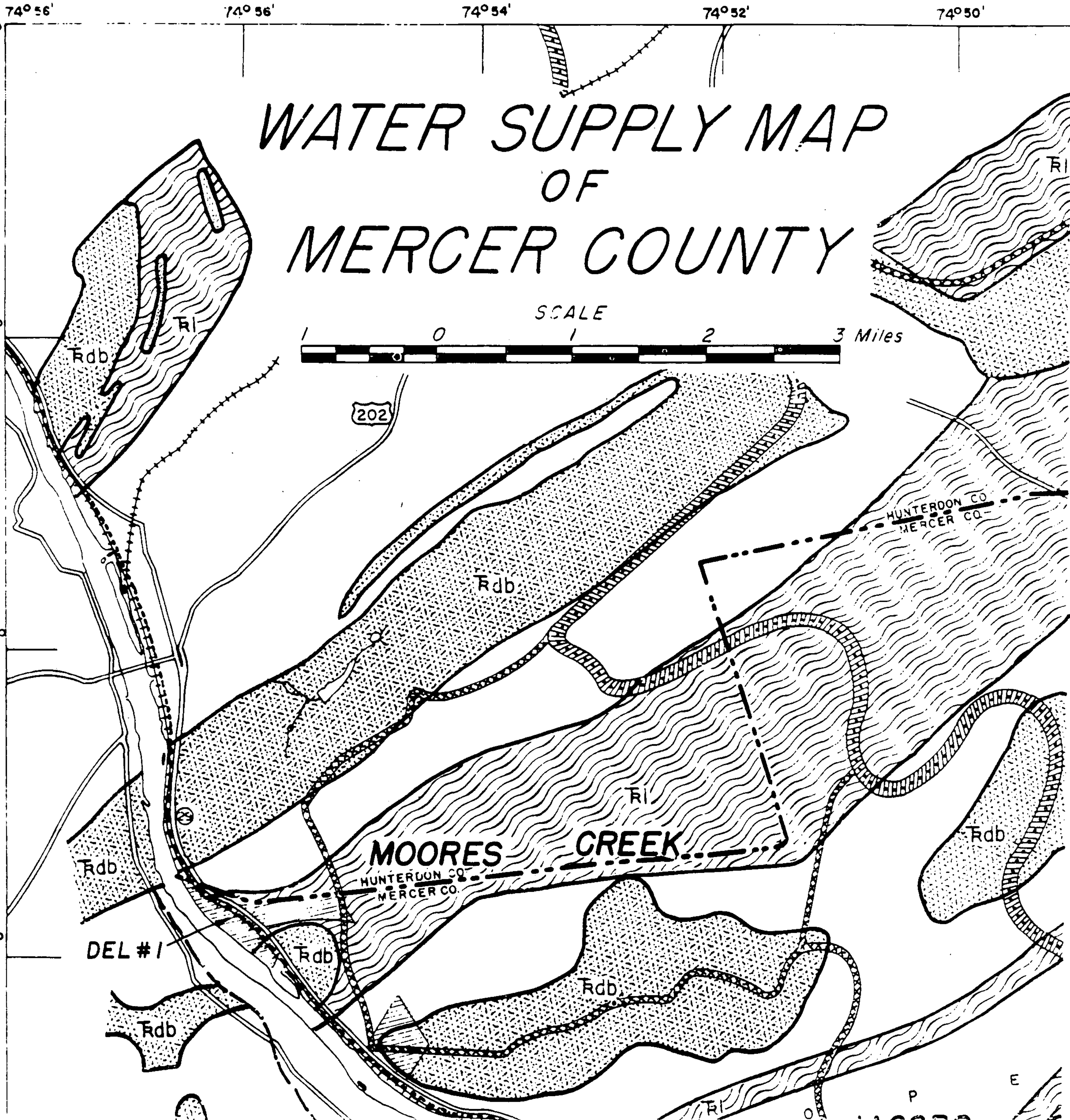
GEOLOGY of the GROUND WATER RESOURCES of MERCER COUNTY

by

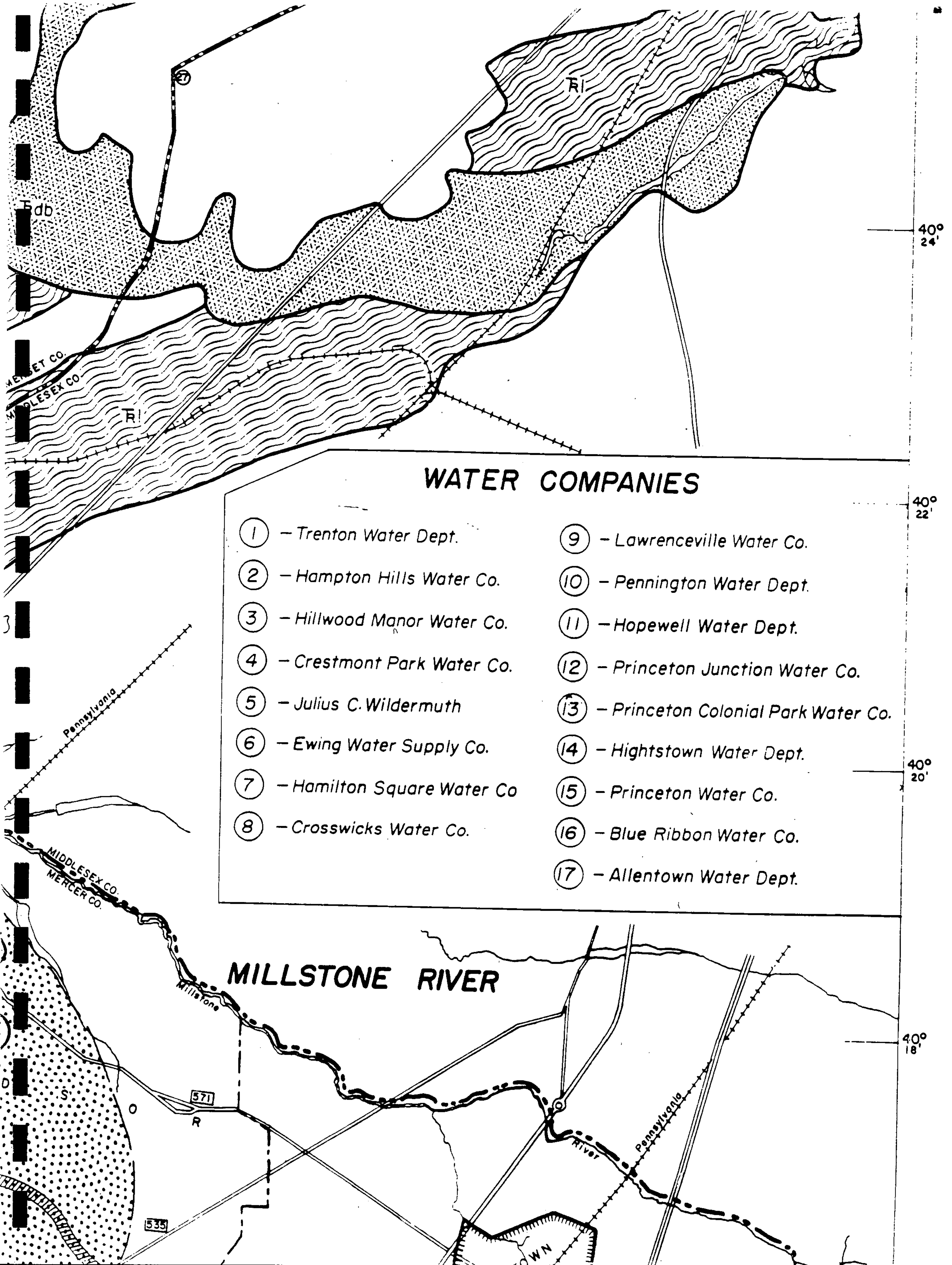
KEMBLE WIDMER,
State Geologist

BUREAU OF GEOLOGY AND TOPOGRAPHY
P. O. BOX 1889
TRENTON, NEW JERSEY 08625

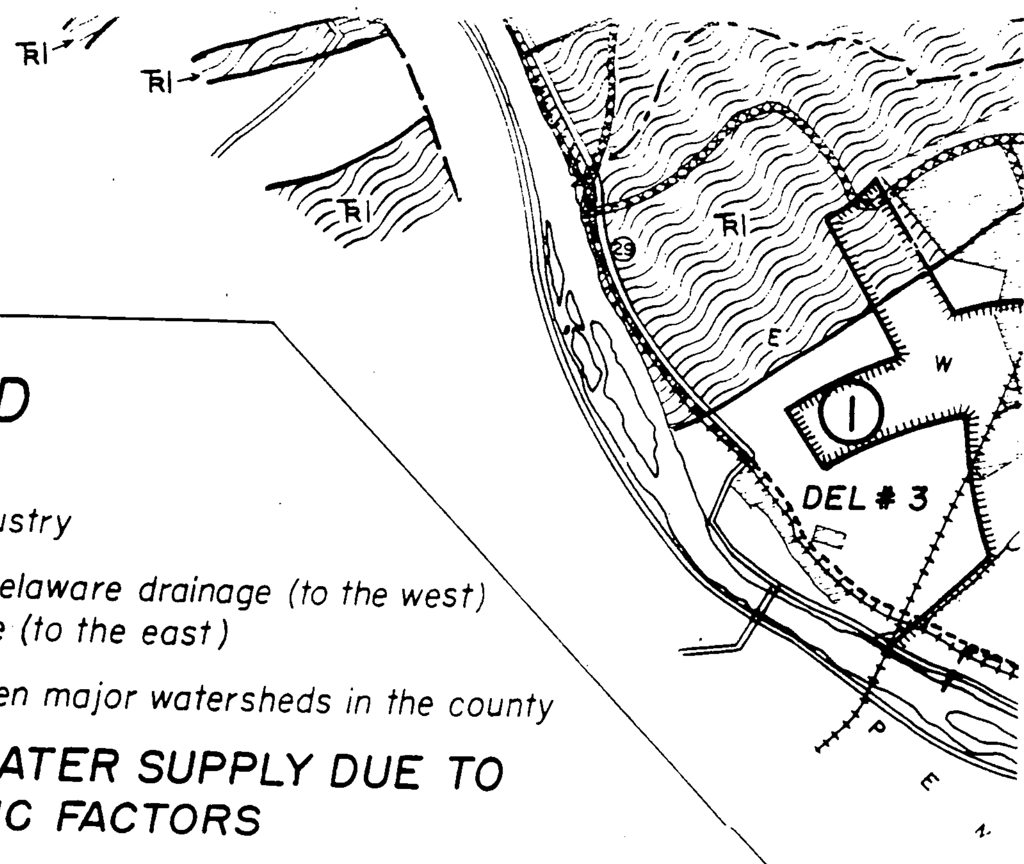
— 1965 —



WATER SUPPLY MAP
OF
MERCER COUNTY
SCALE
1 0 1 2 3 Miles
74° 56'
74° 56'
74° 54'
74° 52'
74° 50'
40° 26'
40° 24'
40° 22'
40° 20'
202
Ŧl
Ŧdb
HUNTERDON CO.
MERCER CO.
MOORES CREEK
DEL #1


WATER COMPANIES
1 – Trenton Water Dept.
2 – Hampton Hills Water Co.
3 – Hillwood Manor Water Co.
4 – Crestmont Park Water Co.
5 – Julius C. Wildermuth
6 – Ewing Water Supply Co.
7 – Hamilton Square Water Co
8 – Crosswicks Water Co.
9 – Lawrenceville Water Co.
10 – Pennington Water Dept.
11 – Hopewell Water Dept.
12 – Princeton Junction Water Co.
13 – Princeton Colonial Park Water Co.
14 – Hightstown Water Dept.
15 – Princeton Water Co.
16 – Blue Ribbon Water Co.
17 – Allentown Water Dept.
MILLSTONE RIVER
Millstone
River
MIDDLESEX CO.
MERCER CO.
Pennsylvania
571
535
40° 24'
40° 22'
40° 20'
40° 18'

Deposits are not shown except on the Pennsylvania side of the Delaware River opposite Hopewell Township. Geology in Pennsylvania taken from Bucks County Report and 1957 GSA Guidebook.



LEGEND

Area zoned for industry

Boundary between Delaware drainage (to the west) and Raritan drainage (to the east)

Boundary line between major watersheds in the county

AREAS OF POOR WATER SUPPLY DUE TO GEOLOGIC FACTORS

TRdb - Diabase

TRl - Lockatong Argillite

P€ - Undifferentiated Precambrian & €h - Hardyston Quartzite

Rock types where ground water potential is poor to inadequate

Area where undifferentiated Precambrian or Hardyston Quartzite are close to the surface and overlying formations are too thin or contain too much clay and silt to produce adequate water supplies.

Current water company service areas

Formation Contact

Roads

130 Federal

33 State

518 County

Turnpike

Boundaries

County

Township

Municipal & Borough

Railroads

Rivers

Streams

Del. & Rar. Canal

Lakes & Ponds

Base Maps: Atlas Sheets 27 & 28

New Jersey Geological Survey 1962

NO

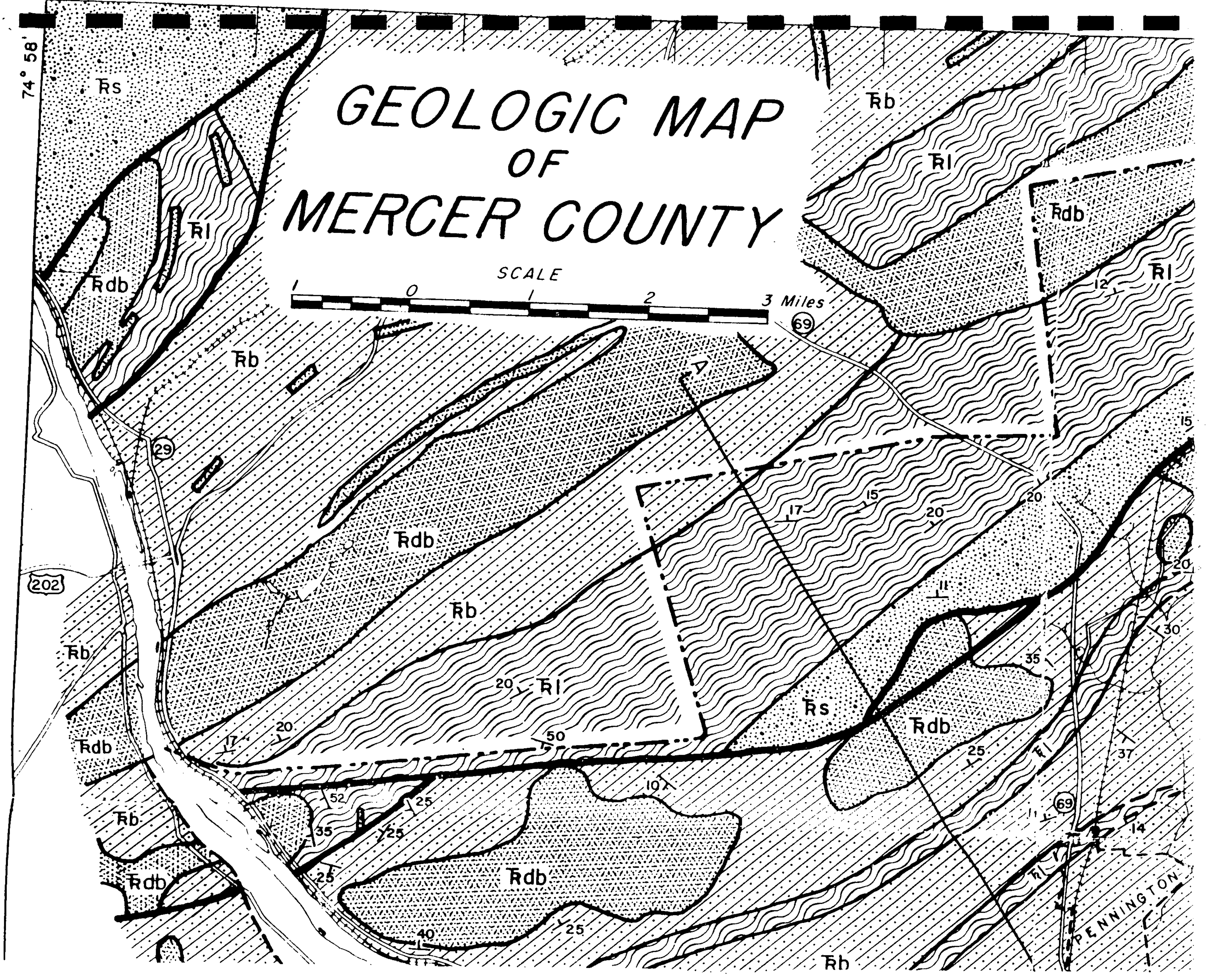
DE

Ri

58'

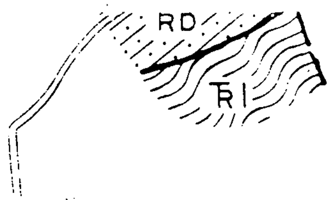
74° 56'

74° 54'



GEOLOGIC MAP
OF
MERCER COUNTY
SCALE
1 0 1 2 3 Miles
74° 58'
Ꞧs
Ꞧl
Ꞧdb
Ꞧb
29
69
202
A
PENNINGTON

well Township. Geology in Pennsylvania taken from Bucks County Report and 1957 GSA Guidebook.



LEGEND

Kmw - Mt. Laurel & Wenonah Sands

Kmt - Marshalltown Formation

Ket - Englishtown Sand

Kwb - Woodbury Clay

Kmv - Merchantville Clay

Kmr - Magothy & Raritan Formations

TRdb - Diabase (Intrusives)

TRb - Brunswick Shale

TRl - Lockatong Argillite

TRs - Stockton Sandstone

Ꞓh - Hardyston Quartzite

PꞒ - Precambrian (Undifferentiated)

20 Strike & Dip of Bedding

Fault

Formation Contact

Dikes

Roads

130 Federal

33 State

518 County

Turnpike

Boundaries

County

Township

Municipal & Borough

Railroads

Rivers

Streams

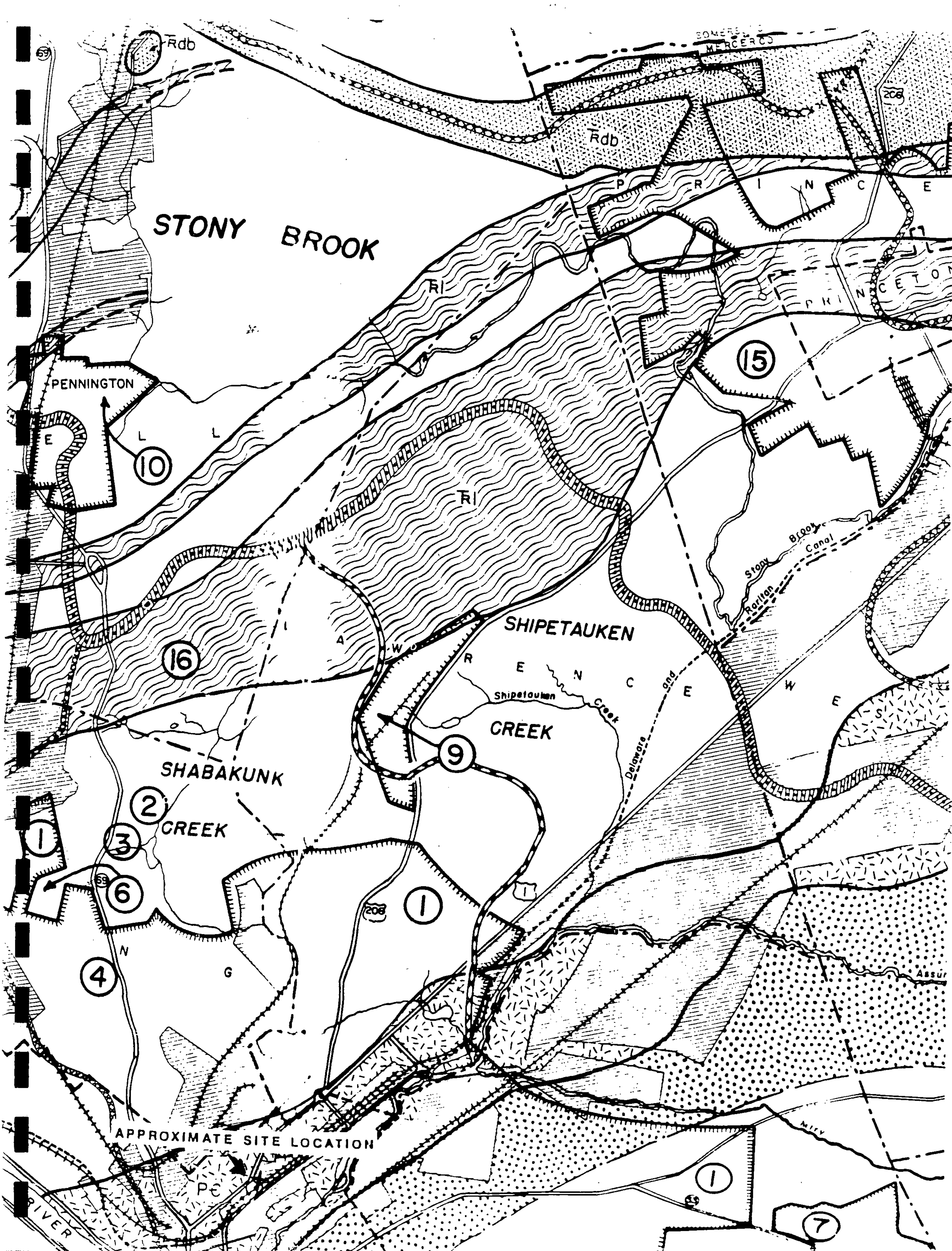
Lakes & Ponds

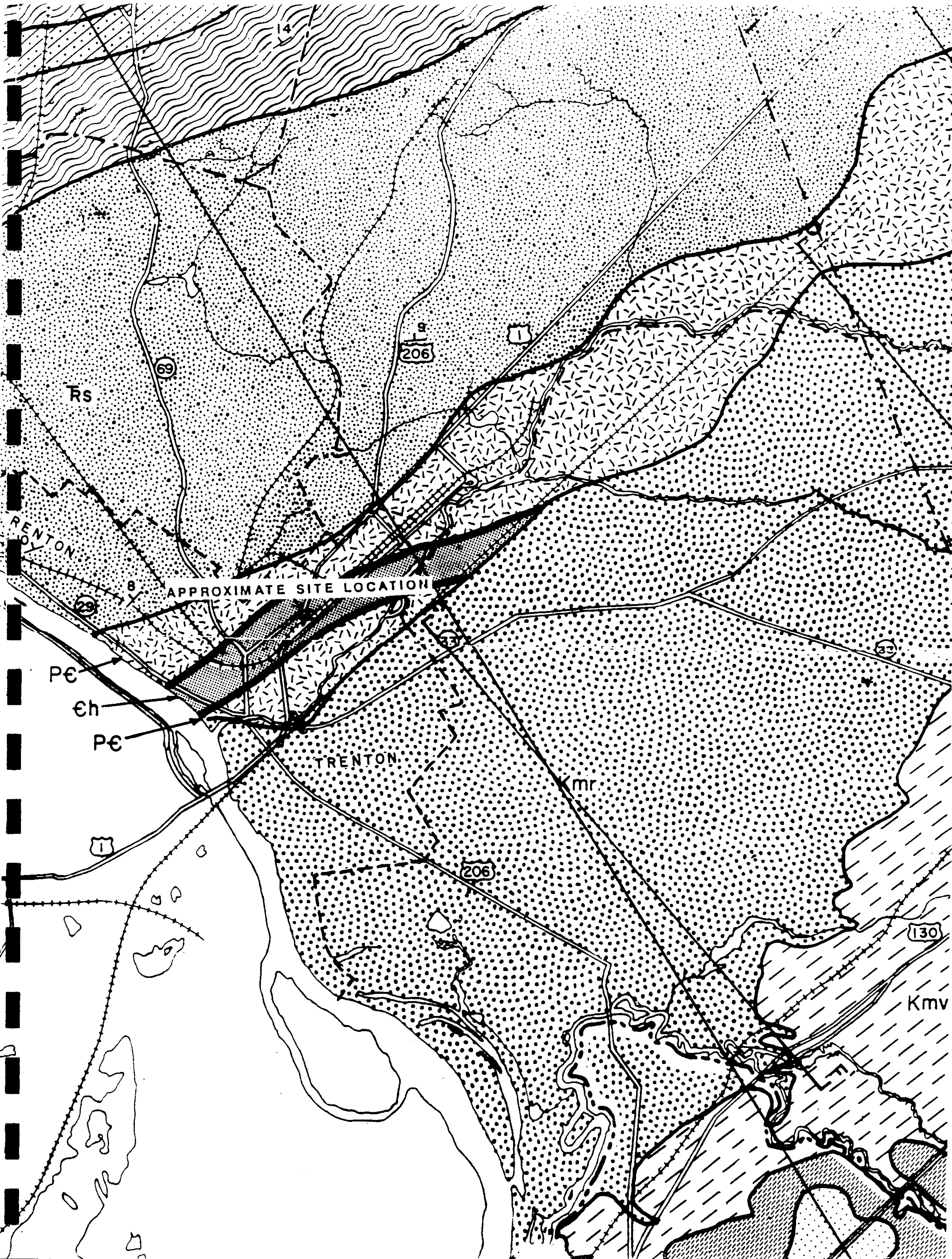
Base Maps: Atlas Sheets 27 & 28

New Jersey Geological Survey 1962

74° 58'

40° 04'


STONY BROOK
PENNINGTON
SHIPETAUKEN
CREEK
Shipetauken Creek
SHABAKUNK
CREEK
Stony Brook
Raritan Canal
Delaware and
APPROXIMATE SITE LOCATION
RIVER
Rdb
TRl
SOMERSET CO
MERCER CO
PRINCETON
LAWRENCE
WEST
10
15
16
9
1
2
3
4
6
7



APPROXIMATE SITE LOCATION
TRENTON
TRENTON
Ꞧs
Kmr
Kmv
P€
€h
P€
206
206
69
29
1
1
33
33
130

SUMMARY

Engineers, officials, realtors, planners, and citizens with an interest in ground water resources will find in this report summaries of reasonable expectations of depth and yield for wells drilled anywhere in Mercer County. Drillers' reports from over 1,000 wells have been analyzed and summarized by geological formation, by township, and with respect to local problems. Maximums, minimums, averages, and probabilities of depth and yield for domestic or industrial wells for any part of Mercer County can be determined from the data provided. Information and maps concerning watershed areas, industrial zones, and water company service areas are also provided.

All water supplies in Mercer County are derived from: (a) the Delaware River along the western border of the county; (b) the Delaware and Raritan Canal running southward along the Delaware River to Trenton and then northeastward following Assunpink Creek, Shabakunk Creek, Stony Brook, and the Millstone River until it leaves the county northeast of Princeton; (c) surface waters from farm ponds, impoundments, or from the minor streams of the county; or (d) from wells. Surface water supplies and their development or utilization are further complicated by laws which limit the movement of water from the Delaware River Basin, the southwestern two-thirds of the county, into the Raritan River Basin, the northeastern third of the county. At the present time a limited amount of water may be, taken through the Delaware and Raritan Canal. There are both legal and physical limits as to the amount of water which can be taken from the canal and utilized in different parts of Mercer County.

Most of the population of Mercer County concentrated in the area around Trenton is supplied by the Trenton Water Company with water drawn from the Delaware River. Other urbanized areas are supplied by water companies depending upon wells. While most of the suburban expansion has so far occurred in areas which can be supplied by existing water companies or where individual wells are not too expensive and are usually adequate, in several townships, particularly in the northern part of the county, pressures have developed in recent years to permit construction of realty improvements whose water requirements exceed or will exceed the ground water supply obtainable within and near their boundaries.

Of the three major industrial zones in Mercer County, all of which cross the Delaware Basin-Raritan Basin Drainage Divide, the southern zone along U. S. Route 130 is supplied by large capacity wells completed in the Raritan formation; the central zone along U. S. Route 1 and the Pennsylvania Railroad mainline has limited ground water supplies but is close to the Delaware and Raritan Canal; and the northern zone, near U. S. Route 69 and the Reading Railroad, has neither surface water supplies nor the expectation of more than moderate supplies from wells.

In short, while most of Mercer County has adequate to moderate water supplies available for domestic and many industrial uses, southern and central Mercer County have the greatest future potential for the development of large supplies from either underground or surface water sources. This generalization, however, must be applied with caution. The areas for some specific uses such as irrigation wells, wells for high rise apartments, or industry with a large water requirement are limited in the county.

Ground water supplies are limited in areas underlain by Precambrian rocks, by argillite and by diabase. Unless surface water supplies or water piped in from outside the area is available, industrial development and housing developments on lots of less than two acres should be discouraged in areas underlain by argillite, by diabase, and perhaps by Precambrian rocks.

The area of Precambrian rocks extends northeastward from Trenton to Princeton Junction. Domestic wells are adequate ranging from 50 gpm to no water with most in the 5 - 9 gpm range. Industrial wells range from 175 gpm to 0 gpm and average about 35 gpm with only about one-third giving more than 50 gpm. Nearly all of the area underlain by Precambrian rocks is covered by Pleistocene sediments which provide well water in some areas.

There are several bands of argillite in northern Mercer County which contain very limited supplies of ground water. Over one-third of the domestic argillite wells give an inadequate 4 gpm or less. One argillite well in ten yields less than 2 gpm. A few industrial wells have been attempted, chiefly in the area between West Trenton and Pennington. The maximum yield for an industrial well was 90 gpm, while over half of the wells gave 20 gpm or less.

Diabase is found in the Rocky Hill sill in northern Mercer County and in several intrusive plugs in Hopewell Township. No industrial wells have been attempted in areas underlain by diabase. Domestic wells range from 100 gpm to nothing with only one well in ten giving water in excess of 10 gpm.

STRATIGRAPHIC COLUMN FOR MERCER COUNTY

Geologic time intervals are arbitrary divisions of unequal length. Each may be matched by one or more geologic formations. An era, the largest division of geologic time, is subdivided into smaller units called periods. Formations, which are mappable rock units, are usually assigned to periods or smaller subdivisions of geologic time, on the basis of distinctive fossils, if present, or distinctive lithology. In the columns below the number in parenthesis indicates the total millions of years before the present when each geologic period began. The rock type given after the formation name is the most common variety. Other types of rocks are also usually present within the formation.

Era	*Period*		*Thickness In County*	*Formation and Rock Type*
		Recent (1/10)	30'?	Soil and alluvium
Cenozoic	Quaternary (1)			
		Pleistocene	150'	Glacial deposits
		Pliocene	. .	
	Tertiary	(70)		Not present in county
		Paleocene	. .	
				Higher Cretaceous formations not present in county.
	Cretaceous (135)		30'	Marshalltown—clay (most exposures outside county)
	(Coastal Plain)		120'	Englishtown—sand
	(Hamilton, Washington, Windsors,		50'	Woodbury—clay
	Hightstown area)		60'	Merchantville—clay
Mesozoic			250–300'	Magothy-Raritan—sand and clay
	Jurassic (180)		. .	Not present in New Jersey
	Triassic (225)			
			4850'	Brunswick—shale
	(Hopewell, Ewing, Lawrence, Princeton area). Igneous rock-intrusive		2900'	Lockatong—argillite
			3300'	Stockton—sandstone
	diabase (Hopewell, Princeton)		1300'	Igneous-diabase
	Permian (270)			Not present in state
	Pennsylvanian			" " " "
	Mississippian (350)			" " " "
Paleozoic	Devonian (400)			Not present in county
	Silurian (440)			" " " "
	Ordovician (500)			" " " "
	Cambrian (600) (Trenton area)		Unknown	Hardyston—quartzite
	Precambrian (Began billions of years ago) (Trenton area)		Unknown	No named formations in county Gabbros; pegmatites; gneisses; schists.

PRECAMBRIAN (PRE-TRIASSIC) ROCKS

Pre-Triassic rocks are found exposed in the Delaware River opposite Trenton, within the bed of Assunpink Creek and elsewhere in excavations in the city, eastward in Lawrence Township, and formerly as far east as Princeton Junction. This group of rocks consists of the Cambrian Chickies or Hardyston quartzite, an alleged equivalent of the Wissahickon schists which may be either Precambrian or early Paleozoic (post-Hardyston) and a meta-gabbro and other igneous rocks such as pegmatite and granite gneiss, which are generally classed as Precambrian in age. The outcrops in Mercer County are too sparse to permit the correlation with certainty of these formations to the more extensive outcrop area and exposures west of the Delaware River. The quartzite has a rather striking continuous outcrop across the river on either side of the Calhoun Street Bridge to Morrisville.

In the 1909 Trenton Folio these rocks are shown as outcropping from beneath the Pleistocene formations as far east as Bakers Basin. On the 1950 State Geologic Map, an outcrop area is indicated just west of Princeton Junction. Well drilling operations in the past few years in the area between Princeton Junction, Edinburg and Trenton suggest that the crystalline rocks lie close to the surface below a thin cover of Pleistocene deposits and underlie a much more extensive area and are much nearer the surface than has heretofore been indicated.

Since all of these rocks are hard crystallines, yielding water only from fractures, the age and lithologic differences are not important for the present study. However, when these rocks are close to the surface, are not capped by Triassic sandstones or Raritan sands and are covered only by Raritan clays or thin Pleistocene deposits containing much silt, the area underlain by these pre-Triassic rocks becomes important in studies of the ground water potential of Mercer County. For convenience in this study, in maps, sections, and discussion, these crystalline rocks are hereafter referred to as Precambrian without regard as to whether they are actually Precambrian gneisses or meta-gabbros, Cambrian quartzites, or younger gneisses and schists.

Field reconnaissance was conducted by the New Jersey Geological Survey in Mercer County during May, 1960 as a preliminary step in the preparation of a geologic base map for the ground water report on the area. The existing geologic maps did not seem to agree with information from new exposures and well data that were not available when the geologic map was revised in 1950.

Prior to commencement of field work, considerable research was conducted on published data on the pre-Triassic rocks shown in the Trenton and Princeton Junction areas on the State Geologic Map. Outcrop localities given in the permanent notes were noted on the new U.S.G.S. 1:24000 quadrangle sheets.

Field checking was started in the Trenton area. Precambrian gneiss in a highly weathered state was found beneath a few feet of overburden in the excavation for a large building 1,500 feet southeast of U. S. Route #1 on that part of the highway between Texas Avenue and the Lawrence Drive-In Theatre. This area was formerly mapped as Triassic on the geologic map. The occurrence of Precambrian gneiss at this locality and as outcrops to the west necessitated moving the Triassic-Precambrian contact in a northwesterly direction nearly one-fourth of a mile.

Reconnaissance was continued in a zone about three miles wide from Trenton to Princeton Junction on both sides but chiefly southeast of U. S. Route #1. All roads in this area crossing the Cretaceous-Triassic contact as shown on the geologic map were traveled. All areas of potential outcrop or exposure were examined including road cuts, stream banks, and excavations for buildings and garbage burial. It soon became evident that the contact zone as mapped was based on inference rather than on outcrop. No identifiable outcrops of Cretaceous or Triassic deposits were found within one-fourth mile of either side of the contact zone as previously mapped. Intensive search disclosed only Pleistocene deposits at or near the surface. Clay was found in the area between the Delaware and Raritan Canal and Assunpink Creek just south of Bakersville. The white and gray clay, upon cursory examination, appeared to be Cretaceous, however, detailed examination and comparison of samples suggests that this clay is a Pleistocene deposit, consisting largely of reworked Raritan Formation and/or Precambrian saprolite materials.

Mention was made in the permanent geologic notes of several Precambrian outcrop areas which apparently were utilized in preparing the State Geologic Map. All of these localities were visited and field-checked for this report, and all apparently have been covered by sanitary land fill or other construction in recent years. One of these locations was on the north side of the railroad at a crossing near Duckpond Run, two miles southwest of Princeton Junction. This, apparently, was concealed by the fill for the construction of a highway overpass. The most famous locality, a few hundred yards southwest of the Princeton Junction Station, is now utilized by West Windsor Township as a dump, and the Precambrian outcropping is no longer visible. However, the yellow and white conglomerate, typical of the basal Triassic, is still visible north of the dump. A newly constructed farm pond, south of the railroad tracks on the Old Post Road several hundred yards southwest of the above-mentioned dump, showed that it bottomed in clays containing blue quartz pebbles characteristic of the nearby Precambrian. All of the area listed as Precambrian was very carefully searched for outcrop, and it is concluded that earlier mapping was based on information from well logs, just as in the case in this report, and on now-vanished outcrops.

Simultaneously with the field check operations, all well records on file in the office were consulted for the area between Trenton and Princeton Junction on either side of the Pennsylvania Railroad main line. The study of well records was made over an area sufficiently wide so that all areas which anyone had previously mapped as Precambrian, as well as those areas where there was reason to believe that the Precambrian was close to the surface, were encompassed.

Twenty-one well records were found adjacent to but outside of the areas formerly mapped as Precambrian. All of these wells first penetrate Pleistocene deposits of one kind or another. Some end in identifiable Precambrian rock, while others penetrate a few feet of either gray or yellow clay. In some of the records, this clay has been interpreted as Cretaceous. It is believed, in view of the material found in other wells in the general area which have penetrated thick sequences of Pleistocene and in view of the character of some of the clays observed at the surface in known Pleistocene deposits, that these clays in the above-mentioned wells are probably reworked Precambrian material. Some of the well logs for these wells were prepared by geologists, but others were prepared by the local drillers who are believed to have sufficient experience in the area to be able to identify the various geologic materials. Only those drillers' logs whose location was surrounded by reliable sample logs which had been described by geologists were used in the study and in the preparation of the geologic cross-sections.

West Windsor Township well 25, although a drillers' log, seems to indicate the existence of a Cretaceous filling in a channel in the Precambrian because the interval between 25 and 80 feet is described as white clay and white sand.

There is a lack of reliable subsurface information in the Great Bear Swamp area. Hamilton Township wells 73, 74, and 75 to the south and southeast of the swamp according to the drillers' logs may penetrate a thin section of Cretaceous before ending in Precambrian rocks. Hamilton Township well 76 appears to penetrate Pleistocene for its entire depth. The Precambrian-Cretaceous contact has therefore been arbitrarily located along the southern portion of Great Bear Swamp. A well drilled in November, 1960 after the revised contact had been drawn in was located just north of the inferred Precambrian boundary. The well struck dark green Precambrian schist at a depth of nine feet.

The shape of the Precambrian outcrop area beneath the Pleistocene suggests that, at several points, valleys or channels trending north-south, or northeast-southwest may have been eroded in the Precambrian basement. One such channel filled with Pleistocene may be indicated by West Windsor well 64 and 95 drilled for Wing Hing Farms. Other well records and geophysical traverses in the area suggest that there are other such channels which may have thin deposits of Cretaceous sediments, a thin residual layer of Triassic rocks, or uneroded weathered Precambrian material in the valley bottom. However, in most of this area between Trenton and Princeton Junction the Cretaceous or Triassic cover has apparently been eroded away until the Precambrian has been exposed and the valleys thus formed have been entirely filled with Pleistocene sediments.

Wells Tapping the Precambrian

In the study of the Precambrian rock area of Mercer County, 119 wells and test borings were plotted on the 1:2400 scale U.S.G.S. Quadrangle maps of the area. Of this group 26 domestic and 41 industrial wells were found to be getting their water from the Precambrian. Twenty other wells were drilled to the Precambrian but secure their water from the overlying formation.

Only four industrial wells in Ewing Township, all close to the Trenton City line draw from the Precambrian. Twenty of the Precambrian wells are industrial wells in Trenton. There are 17 domestic and 7 industrial wells in West Windsor Township all in or around Princeton Junction. The remainder of the Precambrian wells with one exception are in Hamilton and Lawrence Township within a mile of the Pennsylvania Railroad main line. The exception is an unsuccessful irrigation test well in Washington Township nearly three and a half miles south of the railroad.

Domestic wells tapping the joints and fissures in the Precambrian may be expected to yield about 10 gallons per minute from a depth of about 120 feet as shown on the tables below.

CITY OF TRENTON

All of the City of Trenton is served by the Trenton Water Department which gets its water from the Delaware River. However, there are a large number of industrial water wells, most of which were drilled before 1940, in center city and in the industrial zones to the south and east. This Bureau also has records for three domestic wells.

Trenton is shaped like a stubby "T" with the top of the "T" against the Delaware River and the stem extending northeastward along the Assunpink Creek and the Pennsylvania Railroad. Of Trenton's 7.5 square mile area, approximately 3 square miles of the stem and the immediately adjacent top of the bar are underlain by Precambrian rocks. The northern tip of the bar, approximately 1.7 square miles, is underlain by Triassic rocks in which 9 wells have been drilled. With one exception, a domestic well, these wells were drilled for the Trenton State Hospital and the State Home for Girls. The 2.9 square miles of the southern part of the "T" is underlain by only a moderate thickness of the Raritan formation resting on Precambrian crystallines capped by a veneer of Pleistocene sands and gravels. In many cases an effort has been made to obtain water from the overlying unconsolidated sediments whether they be Pleistocene sands and gravels or the sands of the Raritan formation. Eleven wells in this part of Trenton obtain water from the Raritan formation and some 15 have been driven to or obtain water from the underlying Precambrian rocks. Eight wells obtain water from the Pleistocene sands and gravels. Three wells, numbers 5, 6, and 7 were apparently drilled in an unsuccessful effort to obtain water from the Pleistocene gravels and/or the sands of the Raritan formation, both of which were dry at these locations. The wells were drilled a short distance into the Precambrian rocks to depths of only 50 to 55 feet.

Records for 47 industrial wells, drilled within the City of Trenton between 1892 and 1961, are summarized below:

Formation	*No. of Wells*	*YIELD IN GALLONS PER MINUTE*			
		Maximum	*Minimum*	*Average*	*Median*
Precambrian	20	175	0	38	23
Pleistocene	8	200	5	62	50
Stockton	8	602	45	164	121
Raritan	11	1,040	60	383	350

Formation	*No. of Wells*	*DEPTH IN FEET BELOW SURFACE*			
		Maximum	*Minimum*	*Average*	*Median*
Precambrian	20	900	50	365	353
Pleistocene	8	179	26	84	89
Stockton	8	588	200	351	322
Raritan	11	317	80	154	113

The yield was given as "plenty" for well number 21 and a value of 50 gpm was used in the tabulation. Well number 23, giving 550 gpm, is an exceptional case which is discussed in the section on Precambrian wells.

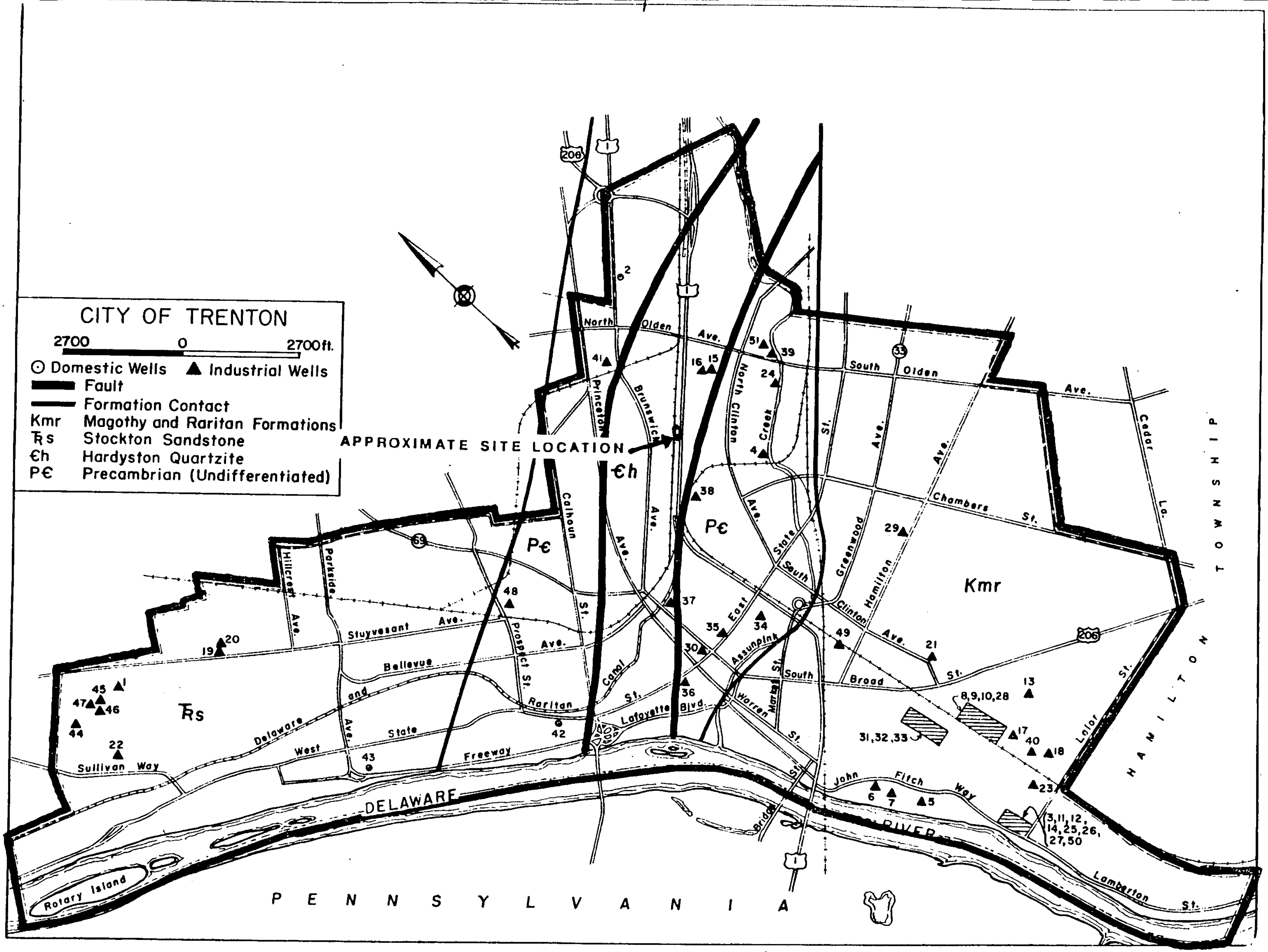
As explained in the section on the Precambrian, depth figures as given should be used with caution. Water may have been obtained at almost any point above the bottom, particularly in the deeper wells: there is no relationship between depth and yield. Average depths for industrial wells are probably fairly reliable for use as a budget figure.

CITY OF TRENTON

Well Number	Casing Diam. (Inches)	GPM	Well Depth (Feet)	Fm.	Casing Length (Feet)	Static Water Level (Feet)	Owner	Year Drilled	Use	Water Level/ Hours Pumped
1	10	602	402	Trs	39	25	Trenton State Hosp.	'57	I	136/24
2	6	15	194	pC	74	30	St. Michaels Church	'55		60/–
3	8	264	117	Kmr	109	39	Metropolis Brewery	'56	I	60/8
4	8	15	75	Qp (P)	..	..	Am. Bilt. Rubber Co.	'52	I	28/–
				pC (B)						
5	6	0	55	pC	18	..	Am. Bridge Company	'46	I	....
6	6	0	50	"	10		"	"	I	....
7	6	0	55	"	20	..	"	"	I	....
8	8	60	90	Kmr (P)	..	..	Columbian Carbon Co.	'52	I	45/–
		(Contaminated-Abandoned)		pC (B)	..	..	(Magnetic Pigment Div.)			
9	8	84	480	pC	103	25	Magnetic Pig. Div. #1	'36	I	160/6
10	8	25	713	"	..	75	" #2	'37	I	250/24
11	8	400	109	Kmr	..	30	Trenton Brewery Co.	'33	I	66½/–
12	8	380	317	Kmr (P)	274		"	"	I	....
				pC (B)	Rock at 280		Qp 36′ Kmr from 36′ or Elev.–3′			
13	8	25	179	Qp (P)	135	57	Chambersburg Dairy	'37	I	83/–
				pC (B)						
14	8	350	86	Kmr	..	30	Trenton Brewing Co.	'45	I	....
15	12	70	598	pC	49	..	Hamilton Rubber Co.	'04	I	170/–
16	8	40	360	"	30	60	Hamilton Rubber Co.	'44	I	180/–
17	8	5	122	Qp (P)	..	..	Roebling & Sons Co.	'36	I	....
	(Abandoned, no water below 67′)			pC (B)						
18	6	560	224	Kmr	208	28	Roebling & Sons Co.	"	I	53/–
19	8	100	200	Trs	..	21	State Home for Girls	'21	I	38/–
	(Condemned and abandoned 1930)									
20	8	130	337	"	304	28	State Home for Girls	'31	I	57/7½
21	6	50	103	Qp (P)	..	28	Roebling & Sons	'36	I	....
	(Contaminated, not used)			pC (B)						
22	8	124	372	Trs	..	41	State Hosp. #11	'43	I	56/20
23	8	175	520	pC	..	60	Stokeley-Van Camp Inc.	'12	I	40/–
	(Yield that is used in Summary; tested at 550 GPM in 1953)									
24	12	100	26	Qp (P)	..	8	Stokes Rubber Co.	'38	I	....
				pC						
25	14	1,040	90	Kmr	..	..	Trenton Brewing Co.	'37	I	60/–
	(Hardness–274 PPM)									

CITY OF TRENTON (Continued)

Well Number	Casing Diam. (Inches)	GPM	Well Depth (Feet)	Fm.	Casing Length (Feet)	Static Water Level (Feet)	Owner	Year Drilled	Use	Water Level/ Hours Pumped
26	. .	300	150	Kmr	. .	. .	Trenton Brewery	. .	I	. . .
27	. .	100	264	"	. .	. .	"	'92	I	. . . .
28	8	50	104	Qp (P) Kmr (B) pC	50	30	Magnetic Pigment Div.	'37	I	. . . .
	(Well is polluted and hard)									
29	. .	11	115	"	. .	. .	Ingersol Watch Factory	'10	I	. . . .
30	8	50	32	Qp	. .	8	S. P. Dunham & Co.	'37	I	. . . .
31	8	15	376	pC	87	. .	Trenton State Prison	'11	I	. . . .
32	10 & 8	47	300	"	69	30	"	"	I	100/½
	(Hard and polluted)									
33	8	2	448	"	79	. .	"	"	I	. . . .
34	8	60	330	"	. .	28	Trenton Times	'37	I	80/—
35	. .	0	730	"	. .	. .	Am. Mechanics Bldg.	. .	I	. . . .
36	8	85	415	"	26	16	Stacy-Trent Hotel	'36	I	86/—
	(Down to 30 gpm in 1938, hardness 374 ppm)									
37	. .	0	170	"	. .	. .	Kerns	'08	I	. . . .
38	. .	15	415	"	. .	. .	Trenton Packing Co.	'24	I	. . . .
39	. .	200	30	Qp	. .	. .	Crescent Insulated Wire Co.	'38 (Prior)	I	. . . .
40	8	340	170	Kmr	134	39	Roebling & Sons	'39	I	133/—
41	6	16	142	pC	54	7	Pierce-Roberts Rub. Co.	'41	I	87/—
42	6	20	36	"	. .	1½	N. J. Manufacturing Assoc.	?		25/7½
	(Tested in 1954)									
43	. .	15	90	Trs?	. .	. .	Bergen	'12		. .
44	8	117	302	Trs	. .	24	State Hospital	'47	I	90/—
45	. .	125	305	"	. .	. .	"	'08	I	. . . .
	(Static level lowered 65' in 24 hours)									
46	. .	75	307	"	. .	. .	"	"	I	100/24
47	. .	45	588	"	. .	65	"	"	I	. . . .
48	. .	100	900	pC	. .	. .	Globe Rubber Works	'98	I	. . . .
	(Shut with dynamite, very hard)									
49	. .	20	125	"	. .	. .	Trenton Coal Yard	'07	I	
	(Lowered in 6 hours)									
50	10	400	80	Kmr	70	30	Metropolis Brewery	'61	I	55/8
51	5 wells yielded small supply			pC	. .	. .	Crescent Insulated Wire	'14 (Prior)	I	Rock at about 42'


CITY OF TRENTON
2700 0 2700 ft.
Domestic Wells
Industrial Wells
Fault
Formation Contact
Kmr Magothy and Raritan Formations
Ŧ̄Rs Stockton Sandstone
Єh Hardyston Quartzite
PЄ Precambrian (Undifferentiated)
APPROXIMATE SITE LOCATION
Єh
PЄ
PЄ
Kmr
Ŧ̄Rs
North Olden Ave.
South Olden Ave.
Princeton Ave.
Brunswick Ave.
North Clinton Ave.
Creek
Calhoun St.
Chambers St.
Cedar La.
Greenwood Ave.
Hamilton Ave.
South Clinton Ave.
East State St.
Assunpink
Hillcrest Ave.
Parkside Ave.
Stuyvesant Ave.
Prospect St.
Bellevue Ave.
Delaware and Raritan Canal
Lafayette St.
South Broad St.
Market St.
Warren St.
West State St.
Sullivan Way
Freeway
John Fitch Way
Lalor St.
Bridge St.
Lamberton St.
DELAWARE RIVER
Rotary Island
PENNSYLVANIA
HAMILTON TOWNSHIP
206
1
33
69
8,9,10,28
31,32,33
3,11,12, 14,25,26, 27,50

HAMILTON TOWNSHIP

About one-fourth of Mercer County's population is found within Hamilton Township's 39.4 square miles. Somewhat more than a third of this area and more than half the people are served by the Trenton Water Department, which obtains water from the Delaware River. An area of about one square mile is served by the Hamilton Square Water Company from wells drawing from the Magothy and Raritan formations.

Since all of Hamilton Township lies within the Delaware River watershed, other surface supplies using river water may be developed if the need arises. The northern half of the township is in the drainage basin of the Assunpink Creek, about half being in the Trenton Water Department service area. About six square miles south of Trenton, all in the area being served by the Trenton Water Department, is drained by minor tributaries of the Delaware. The rest of the township is in the drainage basin of Crosswicks Creek with most of the area, about fifteen square miles, outside the service areas of water companies.

With the exception of a little more than two square miles in the northwestern part of the township south and east of Assunpink Creek, Hamilton Township is underlain by the Magothy and Raritan formations. As one proceeds southeastward the clays of the younger Merchantville and Woodbury formations and the sands of the Englishtown formation overlie the Magothy and Raritan formations in successively higher layers. Pleistocene sand and gravel formations overlie all of the older formations except in some of the deeper stream valleys. The Pleistocene formations usually occur as a thin veneer, but thicknesses of 40-60 feet are not uncommon and in a few places there may be 100 feet or more.

In Hamilton Township the Magothy and Raritan formations are the principal sources of ground water. In the northeastern part of the township where these formations are missing, thin, or are predominately clay or silt, wells have been completed in both the underlying Precambrian rock and in the overlying Pleistocene deposits. The Pleistocene as a source of water in central and southern Hamilton Township has, in general, been overlooked possibly because its most effective utilization will depend on large diameter caisson type or hand-dug wells rather than on the smaller diameter drilled wells. Shallow wells have been completed in the Englishtown formation in and near the extreme southeastern part of the township. In the low-lying western portions of this township adjacent to the Delaware River, there are no well records, but caisson or Raney type wells in the river gravels would probably yield moderate to large amounts of water for industry. This low-lying area, however, is within the service area of the Trenton Water Department.

Records of four domestic and five industrial wells completed in the crystalline rocks of the Precambrian and Hardyston quartzite are, with one exception (#4), within the outcrop area of these formations in the northeastern part of the township. Well #4 apparently encountered no sand in the Raritan and got 1 gpm from the Precambrian.

In the area underlain by the Precambrian and Hardyston rocks, 3 domestic and 12 industrial wells draw from the Pleistocene deposits. In central Hamilton Township 4 other domestic wells have also been finished in the Pleistocene sand and gravel.

All of the remaining 73 wells in Hamilton Township used in this study, with the exception of one well completed in the Englishtown formation in the southern part of the township, draw from the Magothy and Raritan formations. One (#45), a domestic well, was a test and apparently was never used; 43 are domestic wells, and 28 are industrial or public supply wells. Domestic wells drawing from the Raritan will be from 60 to 150 feet deep in the Mercerville-Hamilton Square area, from 120 feet to 180 feet deep in the White Horse-Robbinsville area, and from 150 feet to over 200 feet deep south of U. S. Highway 130. The average depth and median depth have no significance because the Magothy and Raritan sands are increasingly deeper towards the southeast. The deepest domestic well (#45) drawing from the Raritan in Hamilton Township is 304 feet deep; the shallowest (#49), only 40 feet deep, may be drawing from a sandy phase of the Pleistocene deposits. Well #7 is 317 feet deep but draws from the Raritan at less than 156 feet after the casing was pulled back.

The overall geologic relationships and well data suggest that the Magothy and Raritan formations should not be expected to yield large quantities of water north and west of Mercerville; but since the formation thickens to the southeast, wells south and east of Mercerville and Hamilton Square should nearly always be satisfactory if drilled deep enough. Southeast of a line from White Horse to Robbinsville, industrial wells giving 300 - 500 gpm may be expected if properly constructed. Wells of 100 gpm to 200 gpm may not have to be as deep as the larger capacity wells. The depths of industrial wells range from 150 to 220 feet in the Hamilton Square area to in excess of 300 feet deep near the New Jersey Turnpike.

That part of Hamilton Township which lies south of the New Jersey Turnpike cannot be compared to other parts of Mercer County because comparable parts of the geologic formations encountered are found either to the southwest in Burlington County or to the east in Monmouth County. In addition to #83 an Englishtown well and three Hamilton Township wells south of the Turnpike drawing from the Raritan, a tabulation of 15 Englishtown wells and 27 Raritan wells located outside of Mercer County follows the Hamilton Township tabulation. The location of these wells is shown on Plate IV. The Raritan formation is trapped at depths of from 76 to 456 feet for domestic wells and from 73 feet deep to 537 feet deep for industrial and irrigation wells. A few wells have been completed in the overlying Merchantville and several shallow Raritan wells may actually be drawing from the Merchantville or the Pleistocene.

The records for the nine wells in northern Hamilton Township completed in the Hardyston quartzite or Precambrian rocks is summarized below.

	No. of Wells	*YIELD IN GALLONS PER MINUTE*			
		Maximum	*Minimum*	*Average*	*Median*
Domestic	4	20	1	9	7
Industrial	4*	60	7½	30	28

	No. of Wells	*DEPTH IN FEET BELOW SURFACE*			
		Maximum	*Minimum*	*Average*	*Median*
Domestic	4	203	60	170	169
Industrial	5	280	50	151	121

A summary for the Raritan and Pleistocene wells and for Raritan wells south of Mercer County follows. The southern tip of Hamilton Township is at present an area of large farms from which very few well records could be obtained.

* #71 not tested.

DOMESTIC WELLS

Formation	*No. of Wells*	*YIELD IN GALLONS PER MINUTE*			
		Maximum	*Minimum*	*Average*	*Median*
Pleistocene deposits (undifferentiated)	7	15	3	9	10
Magothy and Raritan	44*	47**	7	15	15
Kmr South of Mercer Co.	13	80	7½	32	30

Formation	*No. of Wells*	*DEPTH IN FEET BELOW SURFACE*			
		Maximum	*Minimum*	*Average*	*Median*
Pleistocene deposits (undifferentiated)	7	62	17	50	55
Magothy and Raritan	44	317 (304)	55	115	100
Kmr South of Mercer Co.	13	456	76	230	200

INDUSTRIAL WELLS

Formation	*No. of Wells*	*YIELD IN GALLONS PER MINUTE*			
		Maximum	*Minimum*	*Average*	*Median*
Pleistocene deposits (undifferentiated)	12	228	2	117	132
Magothy and Raritan	27	700	35	246	200
Kmr South of Mercer Co.	12	580	40	361	503

Formation	*No. of Wells*	*DEPTH IN FEET BELOW SURFACE*			
		Maximum	*Minimum*	*Average*	*Median*
Pleistocene deposits (undifferentiated)	12	61	25	42	42
Magothy and Raritan	27	334	67	194	220
Kmr South of Mercer Co.	12	537	73	268	358

* #45 was not tested.

** Well #41 giving 100 gpm was not included in average. Average of wells 17 gpm.

HAMILTON TOWNSHIP

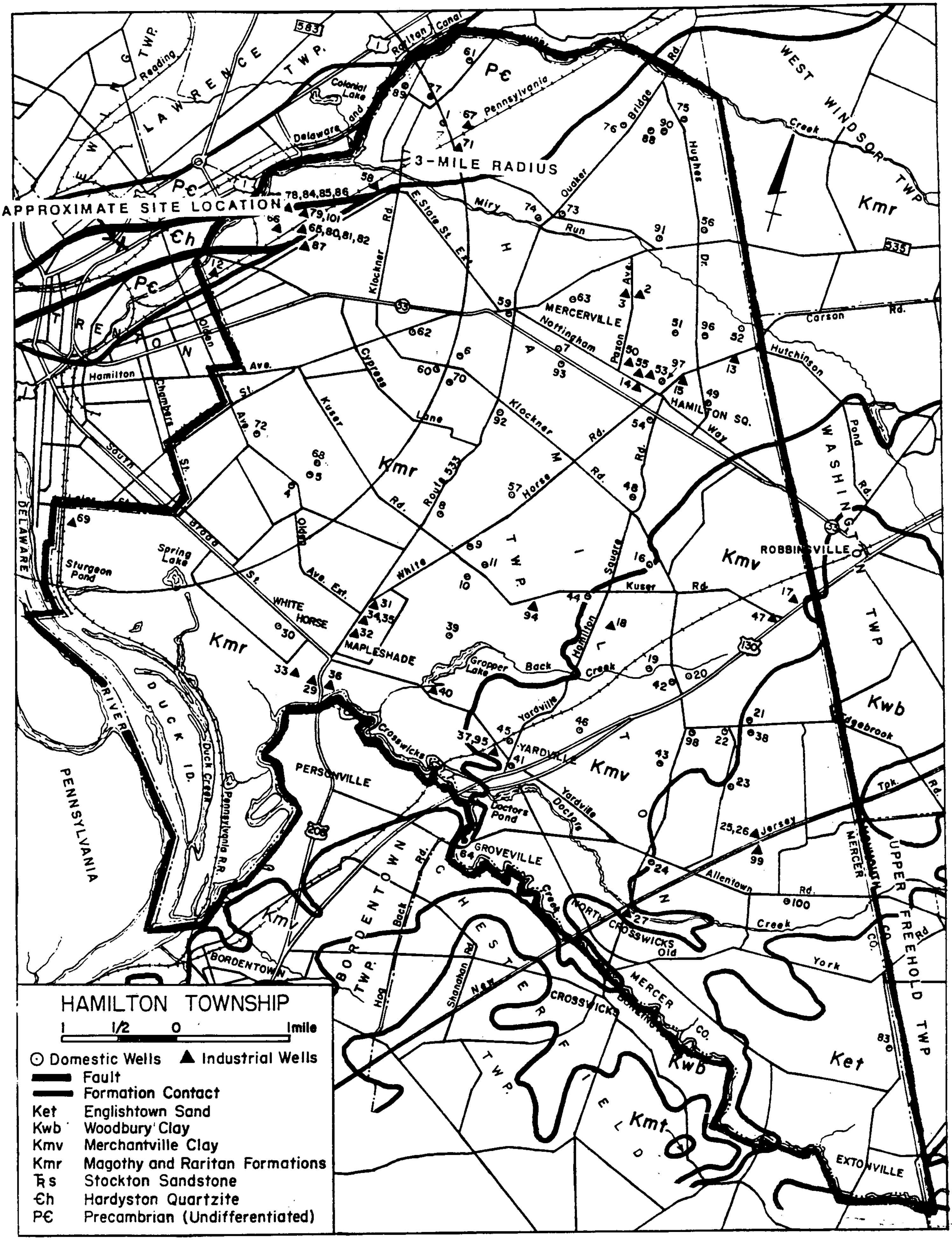
Well Number	Casing Diam. (Inches)	GPM	Well Depth (Feet)	Fm.	Casing Length (Feet)	Static Water Level (Feet)	Owner	Year Drilled	Use	Water Level/ Hours Pumped
1	6	20	203	pC	101	11	Amer. Radiator Standard	'55		187/2
2	10	500 (Abandoned)	150	Kmr	130	18	Hamilton Sq. Water Co.	'56	I	59/168
3	10	700	144	"	124	26	" " " "	'58	I	45/8
4	6	1	205	pG	183	36	Cacavio Bros.	'55		....
5	4	10	64	Kmr	60	18	Wilson	"		45/2
6	6	25	55	"	52	16	S.P.C.A.	'58		19/6
7	6	30	317	Kmr (P) pC (B)	226(?) (Rock at 156 Casing pulled back into Raritan)	23	Agabiti	'54		60/—
8	6	15	51	Qp	48	25	Jarzyk	'57		40/6
9	6	10	52	"	39	25	Armsparger	"		"
10	6	15	85	Kmr	75	40	Pintinalli	"		52/6
11	8	10	142	"	128	50	Emil	"		90/6
12	8	75	60	Qp (P) pC (B)	35	23	Acme Rubber Co.	'56	I	26/6
13	10	460	230	Kmr	200	37	Hamilton Sq. Water Co.	'58	I	160/9
14	8	150	218	"	164	53	" " " "	'54	I	120/—
15	8	50	190	"	175	47	Mercer Rubber Co.	'57	I	130/6
16	3	10	62	"	57	37	Rickard	'54		38/8
17	6	270	259	"	239	56	Walter Reade Theatres	'56	I	110/16
18	8	50	186	"	171	54	Mercer Rubber Co.	'54	I	66/—
19	4	20	215	"	..	45	Gardiner	'57		50/2
20	6	15	125	"	122	25	Amer. Legion Post #33	'59		34/6
21	6	20	236	"	203	35	Biermuth	'55		85/—
22	6	15	141	"	138	25	L. Chryanowski	'57		50/6
23	6	20	162	"	159	25	E. Woods	'60		157/6
24	3	10	127	"	122	40	Nelson	'54		41/10
25	8	300	207	"	..	55	N. J. Turnpike Authority	'55	I	130/9
26	8	250	200	"	173	55	"	"	I	126/12
27	8	500	299	"	249	13	Crosswicks Water Co.	'59	I	....
28	12	183	25	Qp (P) pC (B)	20	8	Thermoid Rubber	'37	I	....
29	8	100	246	Kmr	..	45	White Horse Bowl. Alley	'45	I	65/—
30	6	15	140	"	..	..	So. Broad Street School	'23		....
31	6	100	198	"	..	..	Maple Shade School	'24 ?	I	....
32	6	80 (Pumps 10 gpm)	217	"	..	140	Hartz & Knopf Dairy	'33	I	....
33	8	144	126	"	113	28	Hamilton Twp. Sewerage Plant	'49	I	55/18
34	..	40	70	"	30	30	Mc Galliard	'08	I	....

HAMILTON TOWNSHIP (Continued)

Well Number	Casing Diam. (Inches)	GPM	Well Depth (Feet)	Fm.	Casing Length (Feet)	Static Water Level (Feet)	Owner	Year Drilled	Use	Water Level/ Hours Pumped
35	8	150	220	Kmr	. .	73	McGalliard	'25	I	. . . .
36	2	35	67	"	. .	. .	City of Bordentown	'19	I	. . . .
		(Flows 35 gpm)								
37	6	140	92	"	90	40	Kaye-Tex Manufacturing Co.	'30	I	70/—
38	6	8	155	"	152	68	Tulli	'54		71/—
39	6	15	134	"	. .	30	Kopf	'32		. . . .
		(Irony water, Abd.)								
40	6	100	198	"	. .	. .	Yardville School	'23	I	. . . .
41	. .	100	295	"	. .	. .	Mautz	'09		. . . .
42	6	20	123	"	. .	17	Buckley	'53		58/—
43	6	47	141	"	. .	32	Karzor	'43		100/—
		(Irony)								
44	4	10	73	"	. .	42	Salmon	'51		63/—
45	6	Test	304	"	. .	. .	Chandler	'35		. . . .
		(Slightly irony)								
46	6	15	100	"	. .	. .	Vollwieder	. .		. . . .
47	8	40	110	"	100	50	Reader Bros.	'51	I	70/24
48	4	10	64	"	. .	30	Scalzo	'52		42/—
49	4	10	40	"	. .	18	Brenton	"		30/—
50	12	300	186	"	154	60	Hamilton Sq. Water Co. #5	'54	I	110/—
51	. .	15	200	"	. .	40	Sayer	. .		. . . .
52	6	15	69	"	65	19	Bowes	'53		45/—
53	8	500	220	"	187	51	Hamilton Sq. Water Co. #4	'49	I	82/8
54	4	10	64	"	. .	30	Vorhees	'52		42/—
55	12	600	217	"	. .	45	Hamilton Sq. Water Co.	'34	I	. . . .
56	6	15	65	"	51	. .	Rutkowski	'51		. . . .
57	6	15	117	"	. .	45	Scheidnage	'41		. . . .
58	8	7½	50	pC	28	8	Pennsylvania Railroad	'47	I	42/—
59	6	40	128	Kmr	118	40	Smith	'49		42/4
60	4	15	64	"	. .	25	Gareth	'53		35/—
61	6	4½	135	pC	60	11	Masterson	'49		100/—
62	4	10	90	Kmr	. .	30	Hutchinson	'53		55/—
63	6	20	68	"	63	25	Kundow	'49		27/6
64	6	15	68	"	. .	. .	Anchor Thread Co.	'36		. . . .
65	8	50	38	Qp	23	14	Natl. Sponge Cush. Co.	'57	I	34/6
66	8	80	39	"	. .	. .	Natl. Auto. Fibres Inc.	'40	I	30/—
67	8	60	225	pC	. .	. .	Amer. Rad. & Stan. Sani. Corp.	'24	I	68/—
68	6	15	60	Kmr	57	33	Dringus	'54		. . . .
69	. .	240	198	"	. .	37	Roebling & Sons	'24	I	0/—

HAMILTON TOWNSHIP (Continued)

Well Number	*Casing Diam. (Inches)*	*GPM*	*Well Depth (Feet)*	*Fm.*	*Casing Length (Feet)*	*Static Water Level (Feet)*	*Owner*	*Year Drilled*	*Use*	*Water Level/ Hours Pumped*
70	..	10	68	Kmr	..	30	Shaw	'53		42/—
71	8	?	81	pC	..	..	Sloane-Blabon Corp.	'41	I	....
72	4	3	58	Qp	51	18	Licciardello	'51		40/—
73	6	15	83	Kmr (P) pC (B)	80	6	Mercer Contracting Co.	'55		48/—
74	6	15	60	Kmr (P) pC (B)	57	8	Chevron or Calso Sta.	'57		12/6
75	3	10	61	Kmr	56	56	G. Finkle	'60		50/6
76	6	10	62	Qp	59	15	B. Clark	'57		40/6
77	6	10	135	pC	40	15	G. McCullic	"		135/6
78	6	52	36 (Polluted)	Qp (P) pC	..	..	Thermoid Rubber Co. #4	'20	I	....
79	8	40	280	"	..	18	Sterling Drug Co.	'36	I	130/—
80	8	140	46	Qp (P) pC (B)	27	11	Nearpara Rubber Co.	'52	I	....
81	8	140	49	Qp (P) pC (B)	20	8	"	'41	I	....
82	8	185	35	Qp	25	11	"	'58	I	25/8
83	..	10	35	Ket	..	10	Ewert	'52		....
84	8	15	121	pC	63	8	Thermoid Rubber Co. #9	'20	I	....
85	..	2	36 (Abandoned for lack of water)	Qp	..	..	Thermoid Rubber Co. #1	'20	I	....
86	18 & 12	228 (50 gpm in 1953)	61	Qp (P) pC (B)	..	9	" #2	'37	I	20/8
87	10	125	50	Qp	..	..	Bona Fide Mills	'48	I	....
88	3	5	58	"	55	15	J. Cooper	'61		58/6
89	3	10	17	"	14	..	W. Beebe	"		....
90	3	10	55	"	52	12	D. Perferi	"		....
91	6	15	72	Kmr	65	1	C. Green	'57		15/6
92	6	10	89	"	86	41	Mrs. A. Svochak	'54		45/—
93	3	20	80	"	77	40	Brake Tire & Alignment	'61		....
94	8	50	84	"	78	25	Italian American Club	"	I	68/6
95	8	200	88	"	68	40	Kaye Tex Manufacturing Co.	'60	I	50/5
96	3	15	120	"	114	38	G. Gatson, Jr.	'61		75/6
97	3	12	101	"	..	38	L. Bainbridge	"		40/6
98	4	10	118	"	115	..	J. Karch	'62		....
99	10	600	334	"	317	65	N.J.T.P. Authority	'60	I	154/8
100	4	7	195	"	192	69	T. Cruzlovic	'61		115/6
101	18 & 12	150 (Down to 50 gpm in 1940)	45	Qp	26	3	Sterling Drug Co.	'38	I	20/—



HAMILTON TOWNSHIP
1 1/2 0 1mile
Domestic Wells
Industrial Wells
Fault
Formation Contact
Ket Englishtown Sand
Kwb Woodbury Clay
Kmv Merchantville Clay
Kmr Magothy and Raritan Formations
₹s Stockton Sandstone
€h Hardyston Quartzite
P€ Precambrian (Undifferentiated)
APPROXIMATE SITE LOCATION
3-MILE RADIUS
LAWRENCE TWP.
WEST WINDSOR TWP.
WASHINGTON TWP.
UPPER FREEHOLD TWP.
CHESTERFIELD TWP.
BORDENTOWN TWP.
HAMILTON TWP.
PENNSYLVANIA
DELAWARE RIVER
DUCK ID.
MERCERVILLE
HAMILTON SQ.
ROBBINSVILLE
WHITE HORSE
MAPLESHADE
YARDVILLE
PERSONVILLE
GROVEVILLE
NORTH CROSSWICKS
CROSSWICKS
BORDENTOWN
EXTONVILLE
MERCER CO.
MONMOUTH CO.

REFERENCE NO. 10

Monsanto Co. (Poylchrome Corp.)
584 Rte 130
Hamilton Twp./Mercer County
New Jersey

Monsanto Co., now functioning under the name of Polychrome, is known to have been used for chemical process waste disposal from 1962-1971. No file information at all is available, with the exception of the Eckhardt report listing, which is attached.

Since there is so little information available and the function of the facility is dubious, I recommend a site inspection on a medium priority schedule.

Submitted by: Kathleen Van Hook
Environmental Specialist
NJDEP-HSMA
RCRA 3012 Project

Preliminary Assessment

Monsanto Co. (Polychrome Corp.)
584 Rte 130
Hamilton Twp./Mercer County
New Jersey

EPA

POTENTIAL HAZARDOUS WASTE SITE PRELIMINARY ASSESSMENT
PART 1 - SITE INFORMATION AND ASSESSMENT

I. IDENTIFICATION

01 STATE	02 SITE NUMBER

II. SITE NAME AND LOCATION

01 SITE NAME (Legal, common, or descriptive name of site): Monsanto Co. (Polychrome Corp.)	02 STREET, ROUTE NO., OR SPECIFIC LOCATION IDENTIFIER: 584 Rte 130
03 CITY: Hamilton Twp.	04 STATE: NJ; 05 ZIP CODE: ; 06 COUNTY: Mercer; 07 COUNTY CODE: ; 08 CONG DIST:
09 COORDINATES LATITUDE: 40°11'20" LONGITUDE: 74°39'24"	Block: 598 Lot: 41

10 DIRECTIONS TO SITE (Starting from nearest public road): From Trenton: Take Rte 130 S via I-195. Polychrome is large blue facility on 130 south about 1-1/4 miles down, immediately before Georgia-Pacific facility.

III. RESPONSIBLE PARTIES

01 OWNER (if known): Polychrome Corp.	02 STREET (Business, mailing, residential): P. O. Box 817
03 CITY: Yonkers	04 STATE: NY; 05 ZIP CODE: 10702; 06 TELEPHONE NUMBER: ( )
07 OPERATOR (If known and different from owner):	08 STREET (Business, mailing, residential):
09 CITY:	10 STATE: ; 11 ZIP CODE: ; 12 TELEPHONE NUMBER: ( )

13 TYPE OF OWNERSHIP (Check one)
☒ A. PRIVATE ☐ B. FEDERAL: ______ (Agency name) ☐ C. STATE ☐ D. COUNTY ☐ E. MUNICIPAL
☐ F. OTHER: ______ (Specify) ☐ G. UNKNOWN

14 OWNER/OPERATOR NOTIFICATION ON FILE (Check all that apply)
☐ A. RCRA 3001 DATE RECEIVED: __/__/__ (MONTH DAY YEAR) ☐ B. UNCONTROLLED WASTE SITE (CERCLA 103 c) DATE RECEIVED: __/__/__ (MONTH DAY YEAR) ☐ C. NONE

IV. CHARACTERIZATION OF POTENTIAL HAZARD

01 ON SITE INSPECTION
☐ YES DATE __/__/__ (MONTH DAY YEAR)
☒ NO
BY (Check all that apply) ☐ A. EPA ☐ B. EPA CONTRACTOR ☐ C. STATE ☐ D. OTHER CONTRACTOR ☐ E. LOCAL HEALTH OFFICIAL ☐ F. OTHER: ______ (Specify)
CONTRACTOR NAME(S): ______

02 SITE STATUS (Check one) ☐ A. ACTIVE ☐ B. INACTIVE ☒ C. UNKNOWN

03 YEARS OF OPERATION ______ BEGINNING YEAR ______ ENDING YEAR ☒ UNKNOWN

04 DESCRIPTION OF SUBSTANCES POSSIBLY PRESENT, KNOWN, OR ALLEGED
Organics disposed of in mono industrial waste landfill.

05 DESCRIPTION OF POTENTIAL HAZARD TO ENVIRONMENT AND/OR POPULATION
Possible leaching of contaminants into groundwater.

V. PRIORITY ASSESSMENT

01 PRIORITY FOR INSPECTION (Check one. If high or medium is checked, complete Part 2 - Waste Information and Part 3 - Description of Hazardous Conditions and Incidents)
☐ A. HIGH (Inspection required promptly) ☒ B. MEDIUM (Inspection required) ☐ C. LOW (Inspect on time available basis) ☐ D. NONE (No further action needed, complete current disposition form)

VI. INFORMATION AVAILABLE FROM

01 CONTACT	02 OF (Agency/Organization)		03 TELEPHONE NUMBER	
Kathleen Van Hook	NJDEP-DWM-HSMA		609292-1210	
04 PERSON RESPONSIBLE FOR ASSESSMENT	**05 AGENCY**	**06 ORGANIZATION**	**07 TELEPHONE NUMBER**	**08 DATE**
Kathleen Van Hook	NJDEP	HSMA	609292-1210	11, 5, 84 (MONTH DAY YEAR)

EPA

POTENTIAL HAZARDOUS WASTE SITE
PRELIMINARY ASSESSMENT
PART 2 - WASTE INFORMATION

I. IDENTIFICATION	
01 STATE	02 SITE NUMBER

WASTE STATES, QUANTITIES, AND CHARACTERISTICS

PHYSICAL STATES *(Check all that apply)*

- ☐ A. SOLID
- ☐ B. POWDER, FINES
- ☐ C. SLUDGE
- ☒ D. OTHER Unknown *(Specify)*
- ☐ E. SLURRY
- ☐ F. LIQUID
- ☐ G. GAS

02 WASTE QUANTITY AT SITE *(Measures of waste quantities must be independent)*

TONS ______

CUBIC YARDS ______

NO. OF DRUMS Unknown

03 WASTE CHARACTERISTICS *(Check all that apply)*

- ☐ A. TOXIC
- ☐ B. CORROSIVE
- ☐ C. RADIOACTIVE
- ☐ D. PERSISTENT
- ☐ E. SOLUBLE
- ☐ F. INFECTIOUS
- ☐ G. FLAMMABLE
- ☐ H. IGNITABLE
- ☐ I. HIGHLY VOLATILE
- ☐ J. EXPLOSIVE
- ☐ K. REACTIVE
- ☐ L. INCOMPATIBLE
- ☐ M. NOT APPLICABLE

III. WASTE TYPE

CATEGORY	SUBSTANCE NAME	01 GROSS AMOUNT	02 UNIT OF MEASURE	03 COMMENTS
SLU	SLUDGE			
OLW	OILY WASTE			
SOL	SOLVENTS			
PSD	PESTICIDES			
OCC	OTHER ORGANIC CHEMICALS	Unknown		
IOC	INORGANIC CHEMICALS			
ACD	ACIDS			
BAS	BASES			
MES	HEAVY METALS			

HAZARDOUS SUBSTANCES *(See Appendix for most frequently cited CAS Numbers)*

01 CATEGORY	02 SUBSTANCE NAME	03 CAS NUMBER	04 STORAGE/DISPOSAL METHOD	05 CONCENTRATION	06 MEASURE OF CONCENTRATION

FEEDSTOCKS *(See Appendix for CAS Numbers)*

CATEGORY	01 FEEDSTOCK NAME	02 CAS NUMBER	CATEGORY	01 FEEDSTOCK NAME	02 CAS NUMBER
FDS			FDS		
FDS			FDS		
FDS			FDS		
FDS			FDS		

VI. SOURCES OF INFORMATION *(Cite specific references, e.g., state files, sample analysis, reports)*

Eckhardt Report for N. J.-P. 236 (Attached)

EPA FORM 2070-12 (7-81)

EPA

POTENTIAL HAZARDOUS WASTE SITE
PRELIMINARY ASSESSMENT
PART 3 - DESCRIPTION OF HAZARDOUS CONDITIONS AND INCIDENTS

I. IDENTIFICATION

01 STATE	02 SITE NUMBER

II. HAZARDOUS CONDITIONS AND INCIDENTS

01 [X] A. GROUNDWATER CONTAMINATION — 02 [ ] OBSERVED (DATE: ________) — [X] POTENTIAL — [ ] ALLEGED
03 POPULATION POTENTIALLY AFFECTED: ________ — 04 NARRATIVE DESCRIPTION

Potential due to landfill disposal of chemical waste that may have percolated into the groundwater.

01 [ ] B. SURFACE WATER CONTAMINATION — 02 [ ] OBSERVED (DATE: ________) — [ ] POTENTIAL — [ ] ALLEGED
03 POPULATION POTENTIALLY AFFECTED: ________ — 04 NARRATIVE DESCRIPTION

01 [ ] C. CONTAMINATION OF AIR — 02 [ ] OBSERVED (DATE: ________) — [ ] POTENTIAL — [ ] ALLEGED
03 POPULATION POTENTIALLY AFFECTED: ________ — 04 NARRATIVE DESCRIPTION

01 [ ] D. FIRE/EXPLOSIVE CONDITIONS — 02 [ ] OBSERVED (DATE: ________) — [ ] POTENTIAL — [ ] ALLEGED
03 POPULATION POTENTIALLY AFFECTED: ________ — 04 NARRATIVE DESCRIPTION

01 [ ] E. DIRECT CONTACT — 02 [ ] OBSERVED (DATE: ________) — [ ] POTENTIAL — [ ] ALLEGED
03 POPULATION POTENTIALLY AFFECTED: ________ — 04 NARRATIVE DESCRIPTION

01 [X] F. CONTAMINATION OF SOIL — 02 [ ] OBSERVED (DATE: ________) — [X] POTENTIAL — [ ] ALLEGED
03 AREA POTENTIALLY AFFECTED: ________ (Acres) — 04 NARRATIVE DESCRIPTION

Potential due to disposal of chemical organic waste in industrial waste landfill.

01 [ ] G. DRINKING WATER CONTAMINATION — 02 [ ] OBSERVED (DATE: ________) — [ ] POTENTIAL — [ ] ALLEGED
03 POPULATION POTENTIALLY AFFECTED: ________ — 04 NARRATIVE DESCRIPTION

01 [ ] H. WORKER EXPOSURE/INJURY — 02 [ ] OBSERVED (DATE: ________) — [ ] POTENTIAL — [ ] ALLEGED
03 WORKERS POTENTIALLY AFFECTED: ________ — 04 NARRATIVE DESCRIPTION

01 [ ] I. POPULATION EXPOSURE/INJURY — 02 [ ] OBSERVED (DATE: ________) — [ ] POTENTIAL — [ ] ALLEGED
03 POPULATION POTENTIALLY AFFECTED: ________ — 04 NARRATIVE DESCRIPTION

EPA

POTENTIAL HAZARDOUS WASTE SITE
PRELIMINARY ASSESSMENT
PART 3 - DESCRIPTION OF HAZARDOUS CONDITIONS AND INCIDENTS

I. IDENTIFICATION

01 STATE	02 SITE NUMBER

II. HAZARDOUS CONDITIONS AND INCIDENTS (Continued)

01 ☐ J. DAMAGE TO FLORA — 02 ☐ OBSERVED (DATE: ______) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ K. DAMAGE TO FAUNA — 02 ☐ OBSERVED (DATE: ______) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION (include name(s) of species)

01 ☐ L. CONTAMINATION OF FOOD CHAIN — 02 ☐ OBSERVED (DATE: ______) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☒ M. UNSTABLE CONTAINMENT OF WASTES (Spills/runoff/standing liquids/leaking drums) — 02 ☐ OBSERVED (DATE: ______) ☒ POTENTIAL ☐ ALLEGED
03 POPULATION POTENTIALLY AFFECTED: ______
04 NARRATIVE DESCRIPTION

Potential-it is not known if waste landfill was lined or not.

01 ☐ N. DAMAGE TO OFFSITE PROPERTY — 02 ☐ OBSERVED (DATE: ______) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ O. CONTAMINATION OF SEWERS, STORM DRAINS, WWTPs — 02 ☐ OBSERVED (DATE: ______) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ P. ILLEGAL/UNAUTHORIZED DUMPING — 02 ☐ OBSERVED (DATE: ______) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

05 DESCRIPTION OF ANY OTHER KNOWN, POTENTIAL, OR ALLEGED HAZARDS

III. TOTAL POPULATION POTENTIALLY AFFECTED: ______

IV. COMMENTS

As no file information is available for this address under any of the three names (Monsanto,Polychrome,Yardville Plant),but it is listed in Eckhardt Report as an industrial LF,I recommend a site investigation to determine the quality of the present operation's facility and property.

V. SOURCES OF INFORMATION (Cite specific references, e.g., state files, sample analysis, reports)

Eckhardt Report- P. 236 See Attached

EPA FORM 2070-12 (7-81)

REFERENCE NO. 11

[redacted]

R. Allan Freeze

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GROUNDWATER

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Table 2.2 Range of Values of Hydraulic Conductivity and Permeability

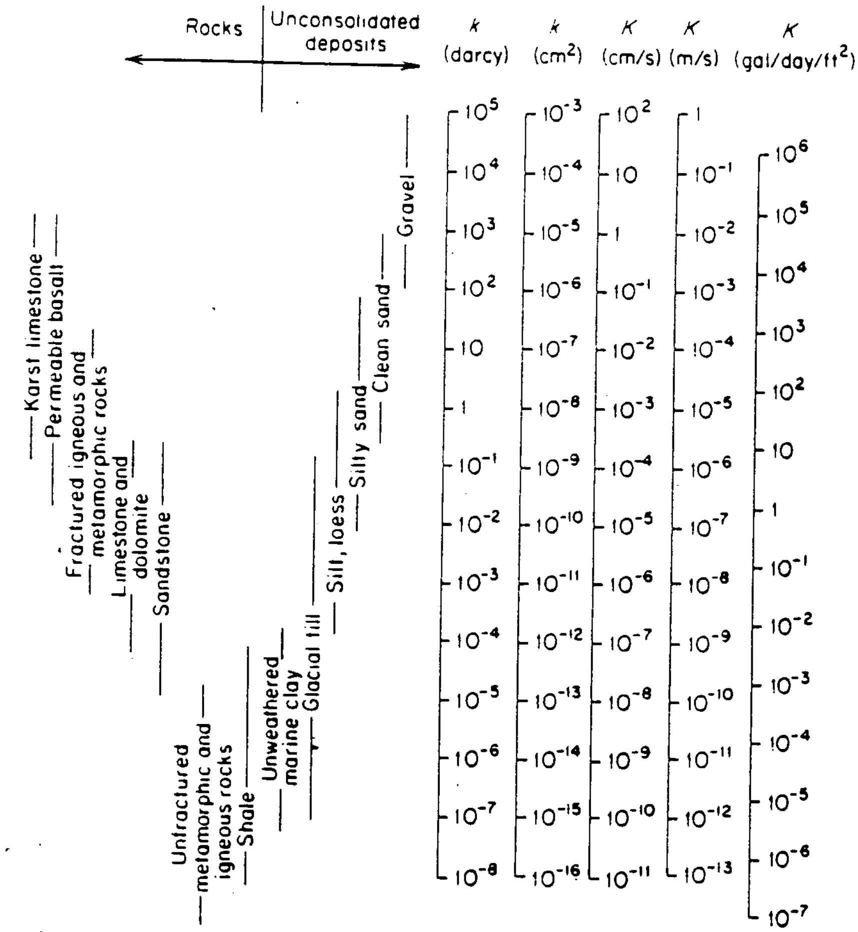

Table 2.3 Conversion Factors for Permeability and Hydraulic Conductivity Units

	Permeability, k*			Hydraulic conductivity, K		
	cm²	ft²	darcy	m/s	ft/s	U.S. gal/day/ft²
cm²	1	1.08×10^{-3}	1.01×10^{8}	9.80×10^{2}	3.22×10^{3}	1.85×10^{9}
ft²	9.29×10^{2}	1	9.42×10^{10}	9.11×10^{5}	2.99×10^{6}	1.71×10^{12}
darcy	9.87×10^{-9}	1.06×10^{-11}	1	9.66×10^{-6}	3.17×10^{-5}	1.82×10^{1}
m/s	1.02×10^{-3}	1.10×10^{-6}	1.04×10^{5}	1	3.28	2.12×10^{6}
ft/s	3.11×10^{-4}	3.35×10^{-7}	3.15×10^{4}	3.05×10^{-1}	1	6.46×10^{5}
U.S. gal/day/ft²	5.42×10^{-10}	5.83×10^{-13}	5.49×10^{-2}	4.72×10^{-7}	1.55×10^{-6}	1

*To obtain k in ft², multiply k in cm² by 1.08×10^{-3}.

REFERENCE NO. 12

ENVIRONMENTAL CONSULTING & MANAGEMENT

ROUX ASSOCIATES INC

1222 FOREST PARKWAY, SUITE 190
WEST DEPTFORD, NEW JERSEY 08066 609 423-8800 FAX 609 423-3220

June 21, 1991

Mr. Anthony Bonasera
NUS Corporation
1090 King Georges Post Road
Suite 1103
Edison, New Jersey 08837

Re: Polychrome Corporation Facility
Yardville, New Jersey
ECRA Case No. 86122

Dear Mr. Bonasera:

Enclosed please find the information you requested during your site visit at the above-mentioned facility on June 5, 1991. The following information has been included as Attachments 1, 2, and 3, respectively:

- Phase III ground-water results
- Depth-to-water measurements collected on site between January 1991 and February 1991 and analysis of the on site flow
- Site history of the Yardville facility between 1961 and 1982

The first two above items are, of course, work performed by ENVIRON Corporation or Polychrome Corporation.

Based on your discussion with Ms. Jo Hanson from Monsanto Corporation on June 6, 1991 excerpts from ENVIRON Corporation's Phase III Sampling Plan Results Report pertinent to the ground water are attached. Because of the volume, the raw laboratory data were not included. If you require the raw data, please let me know and I will make a copy for your files.

A site history concerning the manufacturing/operations between 1961 and 1982 is included. Site operation information between the years of 1982 to the present should be obtained directly from Polychrome Corporation.

Based upon the review of all the site activities conducted to date under the ECRA program, no further action is believed to be appropriate or warranted for the site. Pursuant to ECRA, all areas of concern have been delineated and have been or will be appropriately remediated. The concentrations of volatile organic compounds in MW-4 are documented to be decreasing rapidly.

If you need further information or have any questions, please feel free to contact me at (609) 423-8800 or Ms. Jo Hanson at (314) 694-6127.

Sincerely,

L. Sherrerd Steele, P.G.
Senior Hydrogeologist/Project Manager

LSS/vvf
Enclosures

cc: Ms. Jo Hansen (Monsanto)
Mr. Steve Krchma (Monsanto)
Ms. Carol Surgens (Jones, Day, Reavis & Pogue)

ATTACHMENT 1

PHASE III GROUND-WATER RESULTS

(Excerpts from ENVIRON Corporation's Phase III Sampling Plan Results Report)

PRESENTATION OF THE PHASE III SAMPLING PLAN RESULTS FOR THE FORMER POLYCHROME CORPORATION FACILITY IN YARDVILLE, NEW JERSEY

ECRA Case No. 86122

Volume I of II

Submitted to the
New Jersey Department of Environmental Protection
on behalf of
Polychrome Corporation

Prepared by

ENVIRON Corporation
210 Carnegie Center
Suite 201
Princeton, New Jersey 08540

November 1990

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(continued)

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APPENDICES

I. INTRODUCTION

A. History of ECRA Compliance

Polychrome Corporation ("Polychrome") entered into an Agreement of Sale with Herbert Krumsick on December 18, 1985, and thereafter signed an Administrative Consent Order (ACO) that governs potential cleanup of its former Yardville facility ("the site") under the Environmental Cleanup Responsibility Act (ECRA). Subsequently, Mr. Krumsick sold the facility to the Hillman Group, the current owner of the site.

Polychrome submitted a General Information Submission (GIS) and a Site Evaluation Submission (SES) to the New Jersey Department of Environmental Protection (NJDEP) on February 18, 1986. A review of Polychrome's activities at this facility indicated that it was unnecessary to submit a plan for sampling other than an investigation of the integrity of an underground fuel oil storage tank. The subsequent Petro-Tite® test indicated a net volume change exceeding 0.05 gallons in an hour. A monitoring well was installed subsequently in the presumed downgradient direction proximate to the tank, which was situated partially below the water table. Soil samples were collected during the well installation, and a ground water sample was obtained after the well had been developed and had stabilized. In a May 5, 1986 letter to Edward Hogan, Esq. of Lowenstein, Sandler, et al. (counsel for Polychrome), NJDEP requested that a Sampling Plan be submitted to address potential contamination relating to the underground tank. After subsequent discussions with NJDEP personnel regarding additional sampling requirements, a Sampling Plan was submitted on July 15, 1986. The results from the soil and ground water sampling at the underground tank were submitted as an addendum on September 26, 1986.

The assigned NJDEP Case Manager, Michael Metlitz, requested a site inspection of the building interior, which occurred on February 3, 1987. The remainder of the property was inspected on March 3, 1987. The March 27, 1987 Report of Inspection from the NJDEP, which indicated a number of required actions, was followed by a June 10, 1987 letter to Carol Surgens, Esq., also of Lowenstein, Sandler et al., commenting on the July 15, 1986 Sampling Plan and restating the requirements in the Report of Inspection.

A Revised Sampling Plan, which was designed to investigate the nature and extent of soil contamination[1] as requested in the Report of Inspection, was submitted on July 20, 1987, with an accompanying cover letter addressing issues raised by NJDEP correspondence of March 27 and June 10. The Revised Sampling Plan identified 14 areas of environmental concern (AECs) based on site history prior to Polychrome's ownership and occupancy, results of the site inspections, and NJDEP comments. The locations of the AECs, which are briefly described in Table 1, are shown on Plate 1. Detailed descriptions of the AECs can be found in the Revised Sampling Plan, which was conditionally approved by NJDEP in a June 3, 1988 letter that also identified two additional AECs. Implementation of this plan on August 1 and 2, 1988, involved the collection of a total of 30 soil samples from 12 borings and a storm sewer catch basin; one water sample from a sump; and two pipe insulation samples from the boiler room. Results of this sampling, including a Phase II Sampling Plan and Cleanup Plan, were submitted to NJDEP in September 1988. In November 1988, ENVIRON completed five hand auger borings in the wooded portion of the property. Results of this sampling were discussed in an addendum to the above report submitted in January 1989.

---

1 For this report, "contamination" is defined as concentrations of a particular substance exceeding informal NJDEP-established ECRA cleanup guidelines for soil or ground water (Table 2). ENVIRON is using these guidelines to simplify presentation and interpretation of sampling results, and neither ENVIRON nor Polychrome suggests or concurs that these cleanup guidelines are the appropriate basis for a site cleanup. Polychrome specifically reserves any and all rights with respect to the establishment of appropriate remediation, if any, on a site specific basis pursuant to N.J.A.C. 7:26B-11.1.

TABLE 1
Areas of Environmental Concern

Area of Environmental Concern	Description
1	Soil in vicinity of dumpster which formerly contained PCB-contaminated material.
2	Soil in vicinity of north edge of parking lot, in former disposal site of absorbent materials.
3	Soil adjacent to former drum storage pad.
4	Soil in vicinity of underground fuel oil storage tank.
5	Soil in vicinity of railroad tracks.
6	Soil in a circular zone of distressed vegetation north of the facility.
7	Soil adjacent to a trench located in the wooded area north of the facility.
8	Soil in area of distressed vegetation and debris in area bordering eastern edge of parking lot.
9	Soil in area of distressed vegetation adjacent to propane tanks.
10	Trench which runs along the southern end of the building.
11	Soil adjacent to water tank.
12	Sediments in the storm sewer catch basin.
13	Damaged pipe insulation in boiler room.
14	Sump located adjacent to transformer enclosure.
15	Small depression located in wooded portion of site.
16	Small depression located in wooded portion of site.

609A:PAA006FA.W51

TABLE 2
NJDEP Informal ECRA Action Levels for Soil and Ground Water

Parameter	Soil	Ground Water
Total Petroleum Hydrocarbons (TPHCs)	100 ppm	1,000 ppb
Priority Pollutants:		
Acid Extractable Organics (AEs)	Case-by-case	50 ppb
Base/Neutral Extractable Organics (BNs)	10 ppm	Case-by-case
Pesticides	Case-by-case	Case-by-case
Polychlorinated Biphenyls (PCBs)	1-5 ppm	0.001 ppb
Volatile Organics (VOCs)	1 ppm	Case-by-case
Phenols	Case-by-case	3,500 ppb
Cyanide (CN)	12 ppm	200 ppb
Priority Pollutant Metals (PPMs)		
Antimony (Sb)	10 ppm	NA
Arsenic (As)	20 ppm	50 ppb
Beryllium (Be)	1 ppm	NA
Cadmium (Cd)	3 ppm	10 ppb
Chromium (Cr) - Total	75 ppm	50 ppb
Chromium (Cr6+)	10 ppm	NA
Copper (Cu)	170 ppm	1,000 ppb
Lead (Pb)	250-1,000 ppm	50 ppb
Mercury (Hg)	1 ppm	2 ppb
Nickel (Ni)	100 ppm	NA
Selenium (Se)	4 ppm	10 ppb
Silver (Ag)	5 ppm	50 ppb
Thallium (Tl)	5 ppm	NA
Zinc (Zn)	350 ppm	5,000 ppb
Polycyclic Aromatic Hydrocarbons (PAHs)	10 ppm	50 ppb

ppm: Parts per million (mg/kg)
ppb: Parts per billion (ug/l)
NA : Not available

The Phase I sampling program identified total petroleum hydrocarbon (TPHC) and cadmium contamination in AECs 1 and 5, volatile organic compound (VOC) and base/neutral extractable organic (BN) contamination in AEC 2, and elevated cadmium concentrations in all areas in the wooded portion of the site. In addition, soils underlying the interior trench were found to contain elevated levels of TPHCs, cadmium, arsenic, phenols, VOCs, and polychlorinated biphenyls (PCBs). Concentrations of parameters exceeding informal ECRA cleanup guidelines are shown on Plate 2.

Based on these results and previous observations in AECs 2, 4, and 11, ENVIRON proposed remediation in these areas. In addition, ENVIRON proposed additional sampling in AEC 1 and in the wooded area to confirm Phase I results. The NJDEP, in its October 12, 1989 conditional approval letter, responded to the September 1988 results report and January 1989 addendum, indicating that although the proposed soil sampling was generally acceptable, three monitoring wells should be installed to document ground water quality downgradient of the railroad siding.

ENVIRON implemented the NJDEP-amended Phase II sampling plan in December 1989 and January 1990, completing three monitoring wells, three hollow-stem auger borings, and six hand auger borings. Also, soils were excavated from AECs 2, 4, 10, 11 and 12.

Results of this sampling program, submitted to NJDEP in a March 1990 report, indicated that (1) soil remediation in AECs 2, 4, 11 and 12 has fully addressed the contamination formerly present in those areas; (2) soil contamination was still present in AEC 10; (3) elevated cadmium levels are not present in the wooded portion of the facility; and (4) chlorinated VOCs are present in MW4, the downgradient monitoring well. The March 1990 report included a proposal for installation of two additional monitoring wells, six soil borings in and around the interior floor trench in AEC 10 and one confirmatory sample from AEC 2.

NJDEP conditionally approved this Plan in an August 20, 1990 letter to Carol Surgens, Esq. of Jones, Day, Reavis & Pogue, attorneys for Polychrome Corporation and authorized agent in this ECRA proceeding. In that letter, NJDEP indicated that the no further action proposals for AECs 4, 6, 7, 11, 15 and 16 were acceptable without condition. The additional monitoring well installation, and confirmatory sampling in AEC 2 were approved, with minor additions to the analytical parameters. NJDEP also stated that further sampling was required in AECs 1 and 10, and requested documentation regarding conditions in AECs 5, 12, 13 and 14.

Polychrome responded to a number of these issues in an October 5, 1990 letter to Ms. Sharon Bruder, NJDEP Case Manager, from Mr. William Kraft of ENVIRON. This letter, provided as Appendix A, indicated that Polychrome would augment its sampling program to include the additional sampling requirements for ground water and AEC 10 but that it did not believe that further action was warranted in AECs 1, 5, 12 and 14. ENVIRON concluded that existing sampling data demonstrates that these areas are no longer of concern and respectfully requested that NJDEP provide technical justification for requiring further investigation of these AECs. Lastly, Polychrome indicated that although sampling would be conducted in AEC 2 to verify the absence of acetone, the required analysis for freon in this sample was inappropriate. No NJDEP response to the October 5, 1990 letter has been received to date.

ENVIRON implemented the remainder of the Phase III sampling program on October 8 and 9, 1990, installing two monitoring wells as proposed and three additional soil borings in the interior floor trench in AEC 10 as recommended by NJDEP in its August 20 letter. Also, ENVIRON collected a confirmatory soil sample from AEC 2 to document acetone levels near a previous post-excavation sampling location.

B. Purpose and Scope

In this report ENVIRON presents the results from implementation of the Phase III Sampling Plan. The report discusses the methodologies used to collect samples, presents site-specific hydrogeological and analytical results of soil and ground water sampling, interprets these results in terms of the informal ECRA cleanup guidelines, and finally, recommends further action to satisfy ECRA requirements.

using an OVA so that worst case locations from two of the borings could be analyzed for VOC+15. This screening indicated that the surface sample from Boring 1010 exhibited the greatest OVA response during this sampling program. Thus, this sample was analyzed for the expanded set of analyses. The OVA screening also suggested that the deep sample from Boring 1011 had the highest VOC level in that boring. However, since field observations (i.e., soil discoloration and odor) suggested that the surface sample from that boring was most contaminated, that sample was analyzed for the expanded parameter list.

B. Monitoring Well Installation and Sampling

As proposed in the March 1990 Phase III Sampling Plan, ENVIRON installed two additional monitoring wells to investigate the extent of chlorinated VOCs, and to investigate if a potential source for these constituents could be identified. The actual locations of these wells are shown on Plate 1; the wells were surveyed by James M. Stewart, Inc., professional land surveyors. Both wells were drilled on October 8, 1990 by a driller on the staff of J.E. Fritts & Associates using hollow-stem augers. The wells were completed to depths of 10 and 15 feet, the depth of the Merchantville Clay. These wells were constructed per current NJDEP specifications for wells monitoring unconsolidated formations. Appendix B includes geologic logs and construction specifications for these wells.

These wells were developed on October 9 using a submersible pump and manual bailing. Each well was developed for at least one hour, during which water clarity improved significantly.

All six monitoring wells were sampled on October 23 by AnalytiKEM, Inc. using dedicated, laboratory-prepared, Teflon bailers. Prior to sampling, each well was purged of at least three well volumes, unless the well purged dry, and allowed to recover within two feet of static water level before sampling. As proposed, each well was analyzed for VOC+15. In addition, as required in NJDEP's August 20 conditional approval, MW5 was analyzed for BN+15, PCBs and TDS.

TABLE 3 Actual Sampling Locations and Analyses		
Sampling Location	**Type and Number of Samples with Sampling Depths[1]**	**Analyses**
MW1-MW4, MW6	Ground Water Samples	VOC+15
MW5	Ground Water Sample	VOC+15, BN+15, PCBs, TDS

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Notes: Depths are measured from warehouse floor

TPHCs:	Total Petroleum Hydrocarbons
PCBs:	Polychlorinated Biphenyls
VOC+15:	Volatile Organic Compounds plus the next highest 15 peaks
TDS:	Total Dissolved Solids
BN+15:	Base/Neutral Extractable Organics plus the next highest 15 peaks
As:	Arsenic
Cd:	Cadmium

C. Quality Assurance/Quality Control

1. Decontamination Procedures

Following completion of each soil boring in AEC 10, all sampling equipment was decontaminated using NJDEP-approved methodologies. Sampling equipment was first washed with an Alconox solution, then rinsed with deionized water. The equipment was then rinsed with acetone, allowed to air dry, then rinsed again with deionized water. Sampling equipment used to obtain samples for As and Cd analyses was also rinsed with 10% nitric acid.

2. Field and Trip Blanks

To monitor the effectiveness of field decontamination procedures, one field blank was collected from a decontaminated split-spoon sampler, and analyzed for TPHCs, PCBs, VOC+15, phenols, As and Cd. In addition, to document the effectiveness of laboratory decontamination procedures, a field blank was collected from a laboratory-prepared Teflon® bailer and analyzed for VOC+15, PCBs and BN+15. In addition, a trip blank accompanied the sampling team during the ground water sampling and was analyzed for VOC+15. Laboratory-prepared deionized water was used for all of these samples.

III. GEOLOGIC AND HYDROGEOLOGIC FINDINGS

A. Site Geology and Setting

The Polychrome Corporation facility is located in the Coastal Plain Physiographic Province in an area where Wisconsin-age stratified drift is the surficial deposit. The underlying formation is the Merchantville Clay, a black, glauconitic micaceous clay that is 50 to 60 feet thick. This formation rests disconformably on the Magothy Formation, which is composed of fine white sands and clays, with characteristic carbonized wood. The Raritan Formation underlies the Magothy, but is geologically similar; thus, the two formations are often referred to as one formation.

Ground surface elevations typically range from 60 to 100 feet above mean sea level. Surface water drainage is generally to the northwest, by a stream partially following the railroad siding. The small stream discharges into Back Creek to the north. This creek flows west to the Crosswicks Creek system, which flows southwest into the Delaware River. Approximately half of the property has been developed for industrial use. The remainder is wooded, with moderate to dense undergrowth.

The predominant sediment types at this facility are an orange-brown silty clay, often with gray mottles and gravel or sand, and a medium to coarse sand with up to 50% subrounded gravel. The gravelly sand is frequently interbedded with minor beds of fine silty sand. Black clayey silt is encountered at depths of 8 to 10 feet, beneath which is a gray-brown sandy silt. Geologic logs for the two wells recently installed at the site are provided in Appendix B.

B. Regional Hydrogeology

The Polychrome facility is located in an area underlain by the Magothy and Raritan Formations, the principal aquifer system used for drinking and industrial waters in the region. The coarse, well sorted sand lenses of the Raritan are particularly important for water supply purposes. These formations are isolated hydraulically from the surficial aquifer by the regionally extensive Merchantville Clay.

During the Phase II sampling program, ENVIRON completed a search of wells within one-half mile of the Polychrome site, including well locations from the NJGS Case Index and water withdrawal points as provided by the Bureau of Water Allocation. No wells were identified within this radius; the nearest water withdrawal point in the downgradient direction is more than three miles from the site.

C. Site Hydrogeology

The six monitoring wells at this site are completed in a dense, sandy silt with minor amounts of clay, typical of the glacial stratified drift present at the surface throughout much of the region. These wells are screened above a micaceous silt layer encountered at 8 to 10 feet below grade, likely the upper surface of the Merchantville Clay Formation. Ground water elevations were measured at the six wells on October 23 and November 12, 1990. Table 4 provides elevations collected at these times. The October 23 and November 12 data are shown on Figures 1 and 2 respectively. As these data indicate, the direction of ground water flow is to the north-northeast to east, with a gradient of about 0.005 feet/foot.

It is likely that the monitoring wells at this site are screened across the entire saturated thickness of the surficial aquifer. The Merchantville Clay was encountered during drilling of each well. The bottom of the well screen was set at the surface of the clay. It is also probable that this aquifer discharges to the nearest surface water body, Back Creek, located approximately 1000 feet northeast of the downgradient property boundary. This creek flows west, then south, emptying into Gropp Lake in Yardville.

These ground water elevation data indicate that the direction of flow varies from north-northeast in the portion of the site beneath the warehouse to east in the area west of the warehouse. Flow direction beneath paved areas may be affected by local recharge from two adjoining unpaved areas: the grass area bordering Route 130 and the railroad siding. Despite these localized variations, overall ground water flow is toward Back Creek.

TABLE 4
Ground Water Elevations

Monitoring Well	Date and Ground Water Elevation	
	October 23	November 12
MW1	57.47	59.12
MW2	59.92	60.08
MW3	58.91	58.03
MW4	55.74	55.75
MW5	55.87	55.70
MW6	53.49	53.42

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APPENDIX C

Summarized Laboratory Data Sheets

AnalytiKEM

VIII. Analytical Results

Volatile Organics

Parameter	Method Blank		A23042-1 609A-MW03 GW02		A23042-2 609A-MW02 GW02		A23042-3 609A-MW04 GW02	
			Sample Designation					
Chloromethane	10	U	10	U	10	U	10	U
Bromomethane	10	U	10	U	10	U	10	U
Vinyl Chloride	10	U	10	U	10	U	10	U
Chloroethane	10	U	10	U	10	U	10	U
Methylene Chloride	1.0	J	2.4	J	0.97	J	1.1	J
1,1-Dichloroethene	10	U	10	U	10	U	10	U
1,1-Dichloroethane	10	U	10	U	10	U	10	U
trans-1,2-Dichloroethene	10	U	10	U	10	U	35	
Chloroform	10	U	10	U	10	U	10	U
1,2-Dichloroethane	10	U	10	U	10	U	10	U
1,1,1-Trichloroethane	10	U	10	U	10	U	7.0	J
Carbon Tetrachloride	10	U	10	U	10	U	10	U
Bromodichloromethane	10	U	10	U	10	U	10	U
1,2-Dichloropropane	10	U	10	U	10	U	10	U
trans-1,3-Dichloropropene	10	U	10	U	10	U	10	U
Trichloroethene	10	U	10	U	10	U	18	
Dibromochloromethane	10	U	10	U	10	U	10	U
1,1,2-Trichloroethane	10	U	10	U	10	U	10	U
Benzene	10	U	10	U	10	U	10	U
cis-1,3-Dichloropropene	10	U	10	U	10	U	10	U
2-Chloroethyl Vinyl Ether	10	U	10	U	10	U	10	U
Bromoform	10	U	10	U	10	U	10	U
Tetrachloroethene	10	U	10	U	10	U	89	
1,1,2,2-Tetrachloroethane	10	U	10	U	10	U	10	U
Toluene	10	U	10	U	10	U	10	U
Chlorobenzene	10	U	10	U	10	U	10	U
Ethylbenzene	10	U	10	U	10	U	10	U
m-Xylene	10	U	10	U	10	U	10	U
o,p-Xylene	10	U	10	U	10	U	10	U
Units	(ug/l)		(ug/l)		(ug/l)		(ug/l)	

AnalytiKEM

VIII. Analytical Results (Cont'd)

Volatile Organics

Parameter	Method Blank		A23042-4 609A-MW06 GW01		A23042-5 609A-MW05 GW01		A23042-6 609A-FB 901023		A23042-7 609A-TB 901023	
			Sample Designation							
Chloromethane	10	U	10	U	10	U	10	U	10	U
Bromomethane	10	U	10	U	10	U	10	U	10	U
Vinyl Chloride	10	U	10	U	10	U	10	U	10	U
Chloroethane	10	U	10	U	10	U	10	U	10	U
Methylene Chloride	1.0	J	1.2	J	1.2	J	5.1	J	3.8	J
1,1-Dichloroethene	10	U	10	U	11		10	U	10	U
1,1-Dichloroethane	10	U	10	U	12		10	U	10	U
trans-1,2-Dichloroethene	10	U	10	U	10	U	10	U	10	U
Chloroform	10	U	10	U	10	U	10	U	10	U
1,2-Dichloroethane	10	U	10	U	10	U	10	U	10	U
1,1,1-Trichloroethane	10	U	14		10	U	10	U	10	U
Carbon Tetrachloride	10	U	10	U	10	U	10	U	10	U
Bromodichloromethane	10	U	10	U	10	U	10	U	10	U
1,2-Dichloropropane	10	U	10	U	10	U	10	U	10	U
trans-1,3-Dichloropropene	10	U	10	U	10	U	10	U	10	U
Trichloroethene	10	U	10	U	10	U	10	U	10	U
Dibromochloromethane	10	U	10	U	10	U	10	U	10	U
1,1,2-Trichloroethane	10	U	10	U	10	U	10	U	10	U
Benzene	10	U	10	U	10	U	10	U	10	U
cis-1,3-Dichloropropene	10	U	10	U	10	U	10	U	10	U
2-Chloroethyl Vinyl Ether	10	U	10	U	10	U	10	U	10	U
Bromoform	10	U	10	U	10	U	10	U	10	U
Tetrachloroethene	10	U	4.1	J	10	U	0.91	J	10	U
1,1,2,2-Tetrachloroethane	10	U	10	U	10	U	1.2	J	10	U
Toluene	10	U	10	U	10	U	1.3	J	10	U
Chlorobenzene	10	U	10	U	10	U	1.5	J	10	U
Ethylbenzene	10	U	10	U	10	U	1.1	J	10	U
m-Xylene	10	U	10	U	10	U	10	U	10	U
o,p-Xylene	10	U	10	U	10	U	10	U	10	U
Units	(ug/l)		(ug/l)		(ug/l)		(ug/l)		(ug/l)	

VIII. Analytical Results (Cont'd)

AnalytiKEM

Semivolatile Organics-Base/Neutrals — Sample Designation

Parameter	Method Blank		A23042-5 609A-~~MW05~~ GW01	
N-Nitrosodimethylamine	10	U	10	U
Bis(2-chloroethyl) Ether	10	U	10	U
1,3-Dichlorobenzene	10	U	10	U
1,4-Dichlorobenzene	10	U	10	U
1,2-Dichlorobenzene	10	U	10	U
Bis(2-chloroisopropyl) Ether	10	U	10	U
N-Nitrosodipropylamine	10	U	10	U
Hexachloroethane	10	U	10	U
Nitrobenzene	10	U	10	U
Isophorone	23		10	U
Bis(2-chloroethoxy)methane	10	U	10	U
1,2,4-Trichlorobenzene	10	U	10	U
Naphthalene	10	U	10	U
Hexachlorobutadiene	10	U	10	U
Hexachlorocyclopentadiene	10	U	10	U
2-Chloronaphthalene	10	U	10	U
Dimethyl Phthalate	10	U	10	U
Acenaphthylene	10	U	10	U
Acenaphthene	10	U	10	U
2,4-Dinitrotoluene	10	U	10	U
2,6-Dinitrotoluene	10	U	10	U
Diethyl Phthalate	10	U	10	U
4-Chlorophenyl Phenyl Ether	10	U	10	U
Fluorene	10	U	10	U
N-Nitrosodiphenylamine	5.6	J	10	U
4-Bromophenyl Phenyl Ether	10	U	10	U
Hexachlorobenzene	10	U	10	U
Phenanthrene	10	U	10	U
Anthracene	10	U	10	U
Dibutyl Phthalate	10	U	10	U
Fluoranthene	10	U	10	U
Benzidine	100	U	100	U
Pyrene	10	U	10	U
Butylbenzyl Phthalate	10	U	10	U
3,3'-Dichlorobenzidine	20	U	20	U
Benzo(a)anthracene	10	U	10	U
Bis(2-ethylhexyl) Phthalate	10	U	5.1	J
Chrysene	10	U	10	U
Dioctyl Phthalate	10	U	10	U
Benzo(b)fluoranthene	10	U	10	U
Benzo(k)fluoranthene	10	U	10	U
Benzo(a)pyrene	10	U	10	U
Indeno(1,2,3-cd)pyrene	10	U	10	U
Dibenzo(a,h)anthracene	10	U	10	U
Benzo(g,h,i)perylene	10	U	10	U
Units	(ug/l)		(ug/l)	

VIII. Analytical Results (Cont'd)

EPA/NIH/NBS Nontargetted Library Search

No nontargetted compounds were detected in the following samples:

Semivolatile Method Blank
A23042-7 609A-TB-901023

AnalytiKEM Designation Volatile Method Blank

CAS Number	Compound Name	Fraction	Scan Number	Estimated Concentration (ug/l)
76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	VOA	337	4.9

AnalytiKEM Designation A23042-1

Client Designation 609A-MW03-GW02

CAS Number	Compound Name	Fraction	Scan Number	Estimated Concentration (ug/l)
76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	VOA	343	3.7

AnalytiKEM Designation A23042-2

Client Designation 609A-MW02-GW02

CAS Number	Compound Name	Fraction	Scan Number	Estimated Concentration (ug/l)
76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	VOA	337	3.6

Note: Estimated concentration is calculated against the nearest eluting internal standard.

AnalytiKEM

VIII. Analytical Results (Cont'd)

EPA/NIH/NBS Nontargetted Library Search

AnalytiKEM Designation A23042-3

Client Designation 609A-MW04-GW02

CAS Number	Compound Name	Fraction	Scan Number	Estimated Concentration (ug/l)
67-64-1	2-Propanone (Acetone)	VOA	184	120
76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	VOA	342	3.4

AnalytiKEM Designation A23042-4

Client Designation 609A-MW06-GW01

CAS Number	Compound Name	Fraction	Scan Number	Estimated Concentration (ug/l)
67-64-1	2-Propanone (Acetone)	VOA	173	4,100 *

AnalytiKEM Designation A23042-5

Client Designation 609A-MW05-GW01

CAS Number	Compound Name	Fraction	Scan Number	Estimated Concentration (ug/l)
	None Detected	VOA	---	--
	Unknown Compound	BN	286	21
	Unknown Compound	BN	1546	5.0

AnalytiKEM Designation A23042-6

Client Designation 609A-FB-901023

CAS Number	Compound Name	Fraction	Scan Number	Estimated Concentration (ug/l)
67-64-1	2-Propanone (Acetone)	VOA	184	3,700 *

Note: Estimated concentration is calculated against the nearest eluting internal standard.

* Results obtained from rerun due to saturation in original run.

AnalytiKEM

VIII. Analytical Results (Cont'd)

Polychlorinated Biphenyls

Parameter	Method Blank	Sample Designation A23042-5 609A-MW05 GW01
Aroclor 1016	10 U	10 U
Aroclor 1221	10 U	10 U
Aroclor 1232	10 U	10 U
Aroclor 1242	10 U	10 U
Aroclor 1248	10 U	10 U
Aroclor 1254	10 U	10 U
Aroclor 1260	10 U	10 U
Units	(ug/1)	(ug/1)

General Chemistry

Parameter	Method Blank	Sample Designation A23042-5 609A-MW05 GW01
Total Dissolved Solids	10,000 U	170,000
Units	(ug/1)	(ug/1)

AnalytiKEM

VIII. Analytical Results (Cont'd)

Field Data

1 x Volume

Sample Designation		pH, units	Conductivity, umhos/cm @ 25°C	Temperature, °C
		Parameter		
A23042-1	609A-MW03-GW02	5.22	210	17.7
A23042-2	609A-MW02-GW02	4.58	130	18.4
A23042-3	609A-MW04-GW02	5.42	150	18.2
A23042-4	609A-MW06-GW01	5.61	155	16.8
A23042-5	609A-MW05-GW01	5.29	245	18.4

Parameter

Sample Designation		Depth to Water from TOC, feet	Depth to Bottom from TOC, feet
A23042-1	609A-MW03-GW02	3.05	13.16
A23042-2	609A-MW02-GW02	8.24	17.08
A23042-3	609A-MW04-GW02	9.27	11.64
A23042-4	609A-MW06-GW01	10.40	12.17
A23042-5	609A-MW05-GW01	7.71	14.21

Parameter

2 x Volume

Sample Designation		pH, units	Conductivity, umhos/cm @ 25°C	Temperature, °C
A23042-1	609A-MW03-GW02	5.47	220	17.2
A23042-2	609A-MW02-GW02	4.95	140	17.9
A23042-3	609A-MW04-GW02			
A23042-4	609A-MW06-GW01			
A23042-5	609A-MW05-GW01	5.50	290	18.2

Parameter

3 x Volume

Sample Designation		pH, units	Conductivity, umhos/cm @ 25°C	Temperature, °C
A23042-1	609A-MW03-GW02	5.80	225	16.7
A23042-2	609A-MW02-GW02	5.31	150	17.7
A23042-3	609A-MW04-GW02	5.47	110	18.0
A23042-4	609A-MW06-GW01	5.46	120	17.3
A23042-5	609A-MW05-GW01	5.38	220	18.8

D. Ground Water

Monitoring wells (MWs) 2 through 6 were analyzed for VOC+15, and MW5 was also analyzed for PCBs, BN+15 and TDS. PCBs and BNs were not detected at MW5. VOCs were not detected at MWs 2 and 3, confirming the January 1990 results. Concentrations of all compounds identified at MWs 4, 5 and 6 are provided on Figure 3. A field blank and trip blank were collected during the ground water sampling and analyzed for VOC+15.

These data indicate that low levels of VOCs are present at MWs 5 and 6 where the total concentrations of VOCs were 23 and 18 ppb, respectively. In addition, the total concentration of the four VOCs at MW4 was 149 ppb, a marked decrease from the 398 ppb of the same four VOCs detected at this well in January 1990.

The data from MW5 indicate that the soils beneath the trench are not having a significant impact on ground water quality. First, PCBs and BNs were not found in ground water at MW5 nor was a sheen observed on the water surface during sampling of MW5. Second, none of the VOCs present in AEC 10 were identified at MW5, although the VOCs detected at MW5 may be degradation products of the PCE and TCA present in AEC 10. Continued monitoring is recommended at MW5, as discussed below, to confirm the above conclusion.

Of the VOCs detected at MW4, only TCA and PCE were detected at MW6, which was installed downgradient of MW4. Thus, trichloroethene (TCE) and trans-1,2-dichloroethene, also present at MW4 have not migrated to MW6. Furthermore, the concentrations of VOCs at MW6 are well below those at MW4, and below to minimally above method detection limits, indicating that VOCs have not migrated off-site.

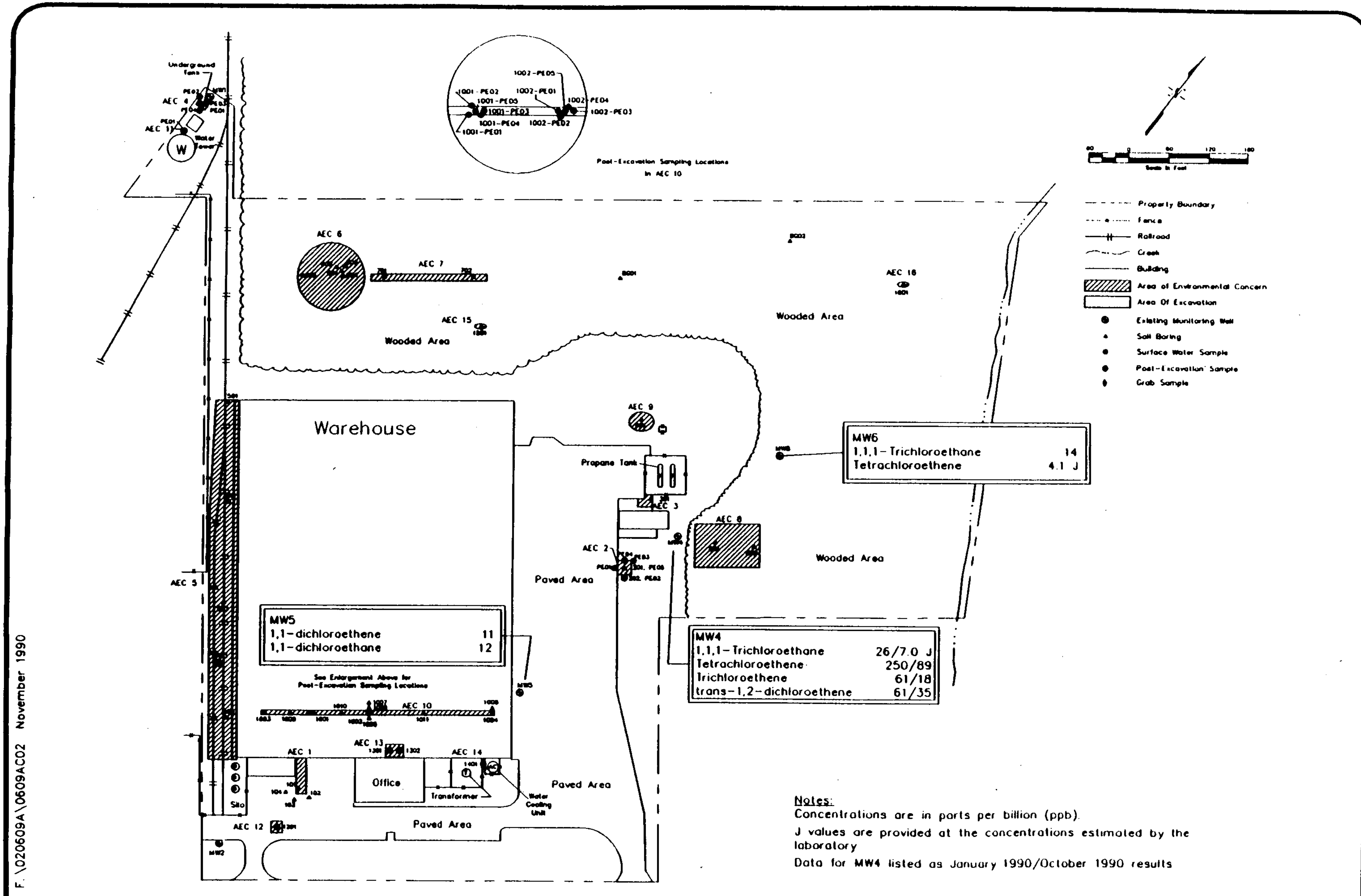
The data from MWs 4 and 6 indicate that contamination at the site is migrating very slowly from MW4 to MW6 and is most likely confined to the site. In addition, these data demonstrate that the level of contamination evident in MW4 is decreasing very rapidly, thus suggesting that MW4 was likely installed proximate to the source of these VOCs. The absence of these VOCs at MW5, completed upgradient of MW4, supports the contention that MW4 was installed proximate to the source area. A likely source of these VOCs is AEC 2, where sorbent material had been observed during an NJDEP inspection in January 1982 during Monsanto's ownership of the site. According to NJDEP's spill report, a sample of this material was collected by NJDEP and analyzed. A Notice of Violation and Offer of Settlement sent to the Monsanto Company in March 1982 regarding the discharge of this material indicated that TCE, toluene and xylene were present in the material. Thus, discharges of VOCs had occurred in AEC 2, and may have impacted ground water. ENVIRON remediated AEC 2, addressing any residual VOC levels in soils possibly contributing to the VOC levels at MW4. The substantial decline in VOC levels at MW4 between the January 1990 and October 1990 sampling rounds further suggests that the source area has been addressed fully. Given the fact that the surficial aquifer system is not used as a source of drinking water and that the well search discussed in the March 1990 report indicated that the closest water withdrawal point to the site is more than three miles away, ENVIRON does not believe that ground water remediation is warranted. This conclusion is supported by the minimal saturated thickness of the surficial aquifer system, the relatively impermeable soils in the vicinity of MW4 and the relatively flat hydraulic gradient which collectively indicate that VOCs are unlikely to migrate to a significant extent. Conversely, the VOC data and hydrogeological information suggest that VOCs in the vicinity of MW4 are being degraded by natural biological or other physical/chemical mechanisms. ENVIRON believes that continued monitoring of VOC levels at MWs 4, 5 and 6 will confirm this conclusion. This sampling is proposed below in Section V.

In addition to these targeted VOCs, the forward library search identified acetone in three samples: the ground water samples for MWs 4 and 6, and the field blank. Since the concentration of acetone in the field blank, 3,700 ppb, is comparable to the level at MW6, 4,100 ppb, and well above the level at MW4, 120 ppb, ENVIRON believes that the presence of acetone is attributable to laboratory contamination. The absence of acetone from the first sample from MW4 supports this conclusion.

E. Quality Assurance/Quality Control

Methylene chloride was detected at estimated concentrations of 5.1 ppb and 3.8 ppb in the field and trip blanks, respectively. Since the estimated concentration of methylene chloride in the ground water samples were lower, between 0.91 and 2.4 ppb, ENVIRON concluded that the presence of methylene chloride in these samples is attributable to laboratory contamination.

Several other targeted VOCs were detected in the field blanks at estimated concentrations below the method detection limits. PCE was identified at an estimated concentration of 0.91 ppb, a level well below that in the ground water samples from MWs 4 and 6. 1,1,2,2-tetrachloroethane was detected at an estimated level of 1.2 ppb, likely as a result of laboratory contamination. Last, several aromatic hydrocarbons -- ethylbenzene chlorobenzene and toluene -- were detected at estimated concentrations between 1.1 and 1.5 ppb. The presence of these constituents is possibly related to automobile exhaust from vehicles operating on-site near the sampling team while the field blank was collected. The presence of nontargeted VOCs in the field blank is discussed above in the section evaluating the ground water results.



ENVIRON

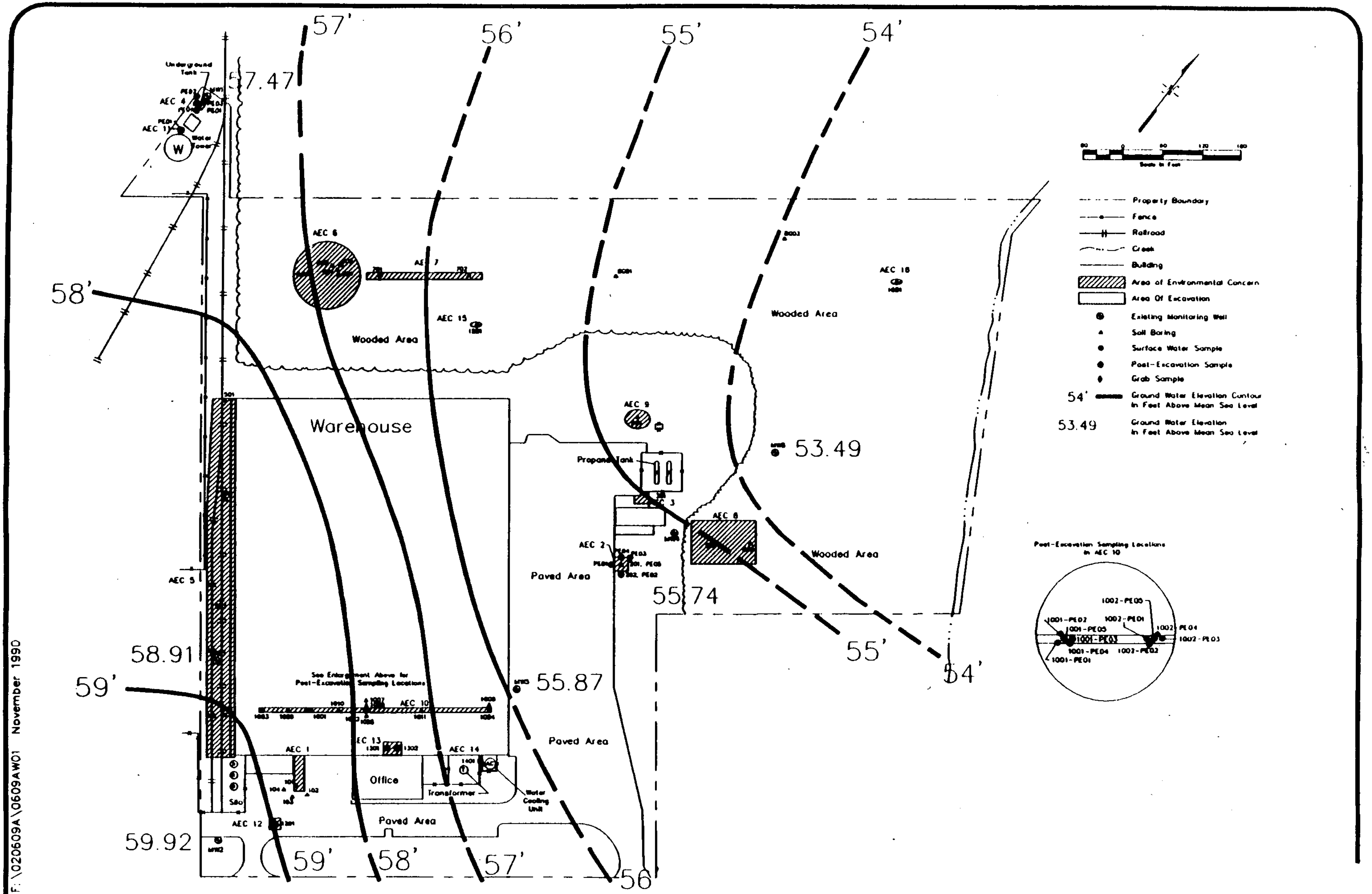
Counsel in Health and Environmental Science

CONCENTRATIONS OF VOLATILE ORGANIC COMPOUNDS IN GROUND WATER

POLYCHROME CORPORATION

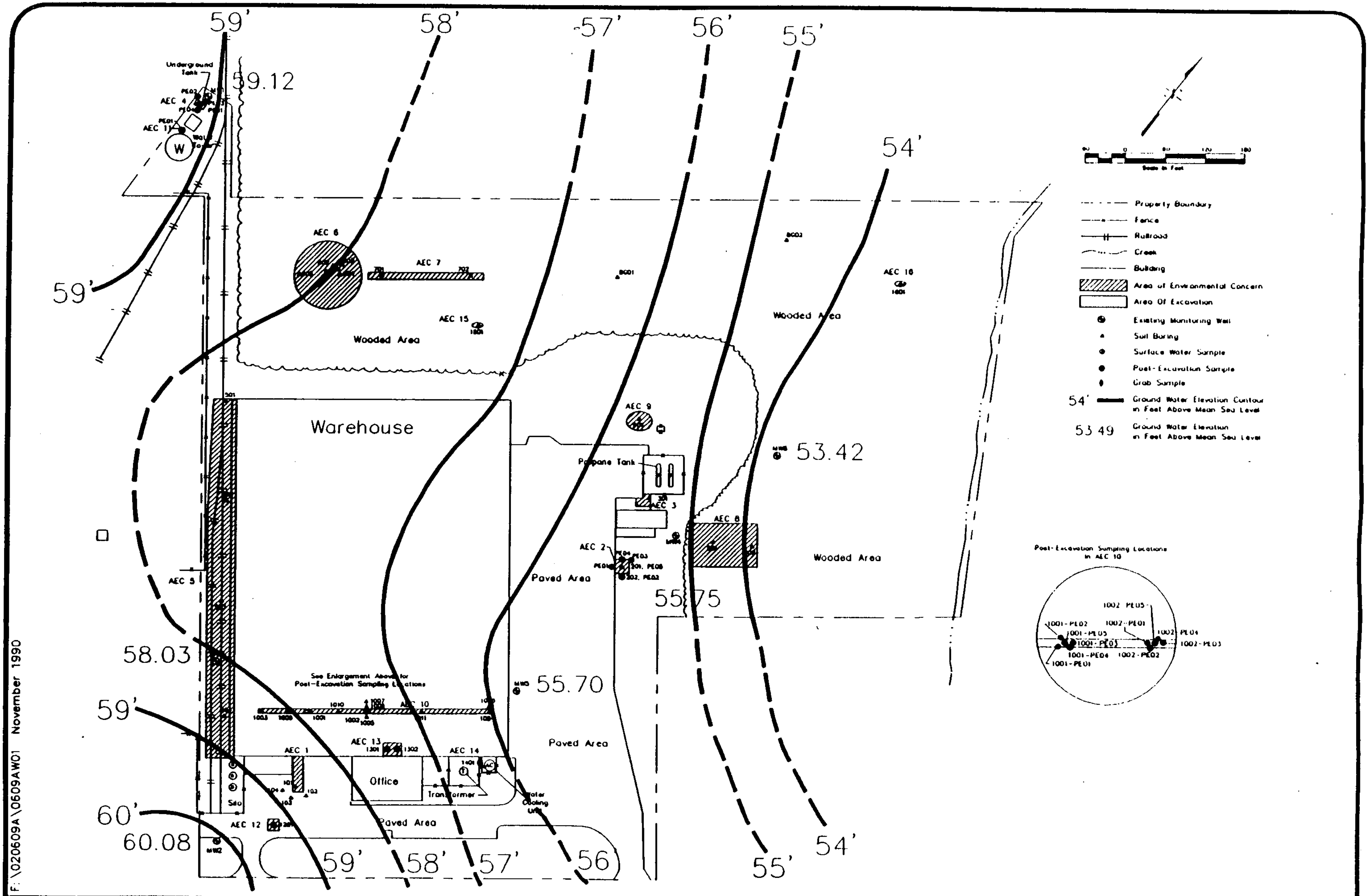
Yardville, New Jersey

Figure 5



ENVIRON
Counsel in Health and Environmental Science

OCTOBER 23, 1990 GROUND WATER ELEVATIONS AND CONTOURS
POLYCHROME CORPORATION
Yardville, New Jersey



ENVIRON
Counsel in Health and Environmental Science

NOVEMBER 12, 1990 GROUND WATER ELEVATIONS AND CONTOURS
POLYCHROME CORPORATION
Yardville, New Jersey

Figure

performed on all samples to identify those samples with elevated TPHC concentrations, but without PCB contamination. Those samples with elevated TPHC levels will then be analyzed for BN+15 to enable ENVIRON to evaluate remediation alternatives. A maximum of 25% of the total sample volume will be analyzed for BN+15. Analyses for As, Cd and phenols, previously conducted in this AEC, are not proposed since the October 1990 soil data demonstrate that these compounds are not present at levels exceeding informal ECRA cleanup guidelines. Table 6 summarizes the proposed sampling depths and analyses.

B. Ground Water

ENVIRON proposes to collect an additional round of ground water samples for VOC analysis from MWs 4, 5 and 6 for several reasons. First, this sampling will confirm the results of the first round of ground water sampling at MWs 5 and 6. Second, a third set of data from MW4 will be used to further document that VOC levels are decreasing rapidly at this location, supporting the no-further-action approach. ENVIRON does not believe that additional sampling of MWs 2 and 3 is necessary since the January and October 1990 data confirm that VOCs are not present at these locations.

0609A:PAA006FA.W51

TABLE 6

Proposed Additional Sampling Locations and Analyses

Sampling Location	Type and Number of Samples and Proposed Depths	Analyses
1012-1024 3 feet from trench	Hollow-Stem Auger Borings 2 Soil Samples • 2.0-4.0 feet[1] • 8.0-8.5 feet	TPHCs, PCBs, VOCs 25% BN+15[2]
MWs 4, 5 and 6	Ground Water Samples	VOCs

[1] Sample to be collected from a six-inch interval within this range based on the trench depth closest to the sampling location.

[2] A maximum of 25% of the total sample volume to be analyzed for BN+15

Note:
- TPHCs: Total Petroleum Hydrocarbons
- PCBs: Polychlorinated Biphenyls
- VOCs: Volatile Organic Compounds
- BN+15: Base/Neutral Extractable plus the next highest 15 peaks

0609A:PAA006FA.W51

APPENDIX B

Monitoring Well Construction Specifications and Certification Forms

Polychrome, Yardville, NJ

Boring No. 1003

Geologic Log

0.0 - 0.5'	Concrete and crushed-stone fill
0.5 - 9.0'	Yellow-beige to light brown, moderately dense, dry, moderately sorted, sandy silt, clayey at 3 to 4'
9.0 - 9.5'	Dark gray to black, dense, dry, silty clay

Drilling Specifications

Drilling Method:	Hollow-stem Auger
Rig:	CME-45
Drilling Company:	Empire Soils Investigations, Inc.
Date Drilled:	April 20, 1990
Plugging Material:	Grout

Split Spoons

Split Spoon No.	Depth	Blow Counts	Hammer	Recovery
1	0 - 2.0' bgs	0, 9, 2, 2	140 lb	4"
2	3.5 - 5.5' bgs	2, 1, 4, 5	140 lb	12"
3	5.5 - 7.5' bgs	6, 8, 7, 10	140 lb	20"
4	7.5 - 9.5' bgs	3, 5, 7, 8	140 lb	24"

Samples Collected

Sample ID No.	Date	Analyses	Depth
609A-1003-SB01	4/20/90	TPHC, PCB	0.5 - 1.0'
609A-1003-SB02	4/20/90	TPHC, PCB	4.0 - 4.5'
609A-1003-SB03	4/20/90	TPHC, PCB	8.5 - 9.0'

Polychrome, Yardville, NJ

Boring No. 1004

Geologic Log

0.0 - 1.0'	Concrete and crushed-stone fill
1.0 - 1.2'	Orange, loose, dry, moderately sorted, silty medium-sand
1.2 - 10.5'	Light brown to brown, moderately dense, dry, clayey silt to silty clay containing small, rounded pebbles
10.5 - 10.9'	Dark gray, dense, dry, moderately sorted, silty clay

Drilling Specifications

Drilling Method:	Hollow-stem Auger
Rig:	CME-45
Drilling Company:	Empire Soils Investigations, Inc.
Date Drilled:	April 20, 1990
Plugging Material:	Grout

Split Spoons

Split Spoon No.	Depth	Blow Counts	Hammer	Recovery
1	1.0 - 3.0' bgs	12, 8, 10, 10	140 lb	16"
2	3.0 - 5.0' bgs	12, 7, 8, 7	140 lb	12"
3	5.0 - 7.0' bgs	4, 4, 7, 8	140 lb	18"
4	7.0 - 9.0' bgs	10, 12, 17, 19	140 lb	24"
5	9.0 - 11.0' bgs	0, 10, 11, 13	140 lb	22"

Samples Collected

Sample ID No.	Date	Analyses	Depth
609A-1004-SB01	4/20/90	TPHC, PCB	1.0 - 1.5'
609A-1004-SB02	4/20/90	TPHC, PCB	5.5 - 6.0'
609A-1004-SB03	4/20/90	TPHC, PCB	10.0 - 10.5'

Polychrome, Yardville, NJ

Boring No. 1005

Geologic Log

0.0 - 0.5'	Concrete and crushed-stone fill
0.5 - 3.0'	Yellow-beige, moderately dense, dry, poorly sorted, sandy and clayey silt to clayey sand
3.0 - 7.5'	Light brown and light gray, moderately dense, dry, moderately sorted, clayey silt

Drilling Specifications

Drilling Method:	Hollow-stem Auger
Rig:	CME-45
Drilling Company:	Empire Soils Investigations, Inc.
Date Drilled:	April 20, 1990
Plugging Material:	Grout

Split Spoons

Split Spoon No.	Depth	Blow Counts	Hammer	Recovery
1	0.0 - 2.0' bgs	0, 7, 9, 11	140 lb	18"
2	2.0 - 4.0' bgs	10, 11, 10, 9	140 lb	18"
3	4.0 - 6.0' bgs	7, 6, 4, 8	140 lb	6"
4	6.0 - 8.0' bgs	12, 11, 10, 11	140 lb	18"

Samples Collected

Sample ID No.	Date	Analyses	Depth
609A-1005-SB01	4/20/90	TPHC, PCB	1.0 - 1.5'
609A-1005-SB02	4/20/90	TPHC, PCB	3.0 - 3.5'
609A-1005-SB03	4/20/90	TPHC, PCB	6.0 - 6.5'

Polychrome, Yardville, NJ

Boring No. 1006

Geologic Log

0.0 - 0.5'	Concrete and crushed-stone fill
0.5 - 2.0'	Yellow-beige, moderately dense, dry, poorly sorted, clayey and sandy silt
2.0 - 2.8'	Yellow, moderately dense, dry, moderately sorted silty medium sand
2.8 - 7.3'	Light brown, dense, dry, moderately sorted, clayey silt

Drilling Specifications

Drilling Method:	Hollow-stem Auger
Rig:	CME-45
Drilling Company:	Empire Soils Investigations, Inc.
Date Drilled:	April 20, 1990
Plugging Material:	Grout

Split Spoons

Split Spoon No.	Depth	Blow Counts	Hammer	Recovery
1	0.0 - 2.0' bgs	0, 7, 11, 15	140 lb	12"
2	2.0 - 4.0' bgs	14, 11, 7, 9	140 lb	18"
3	4.0 - 6.0' bgs	6, 5, 6, 7	140 lb	8"
4	6.0 - 8.0' bgs	9, 5, 5, 7	140 lb	15"

Samples Collected

Sample ID No.	Date	Analyses	Depth
609A-1006-SB01	4/20/90	TPHC, PCB	1.0 - 1.5'
609A-1006-SB02	4/20/90	TPHC, PCB	3.0 - 3.5'
609A-1006-SB03	4/20/90	TPHC, PCB	6.0 - 6.5'

Polychrome, Yardville, NJ

Boring No. 1007

Geologic Log

0.0 - 0.5'	Concrete and crushed-stone fill
0.5 - 2.0'	Yellow, moderately loose, dry, moderately sorted, sandy silt
2.0 - 3.3'	Yellow-beige, moderately dense, dry, moderately sorted, silty medium sand
3.3 - 3.8'	Light gray, dense, dry, moderately sorted, silty clay
3.8 - 7.5'	Light brown, moderately dense, dry, moderately sorted, silty clay to clayey silt

Drilling Specifications

Drilling Method:	Hollow-stem Auger
Rig:	CME-45
Drilling Company:	Empire Soils Investigations, Inc.
Date Drilled:	April 20, 1990
Plugging Material:	Grout

Split Spoons

Split Spoon No.	Depth	Blow Counts	Hammer	Recovery
1	0.0 - 2.0' bgs	0, 26, 18, 24	140 lb	12"
2	2.0 - 4.0' bgs	26, 16, 15, 17	140 lb	18"
3	4.0 - 6.0' bgs	3, 6, 6, 5	140 lb	12"
4	6.0 - 8.0' bgs	7, 6, 7, 9	140 lb	18"

Samples Collected

Sample ID No.	Date	Analyses	Depth
609A-1007-SB01	4/20/90	TPHC, PCB	1.0 - 1.5'
609A-1007-SB02	4/20/90	TPHC, PCB	3.0 - 3.5'
609A-1007-SB03	4/20/90	TPHC, PCB	6.0 - 6.5'

Polychrome, Yardville, NJ

Boring No. 1008

Geologic Log

0.0 - 0.5'	Concrete and crushed-stone fill
0.5 - 3.5'	Yellow-orange, moderately dense, dry, moderately sorted, silty medium sand
3.5 - 4.3'	Light brown, moderately dense, dry, moderately sorted, sandy silt
4.3 - 7.2'	Light brown and light gray, moderately dense, dry, moderately sorted, silty clay to clayey silt

Drilling Specifications

Drilling Method:	Hollow-stem Auger
Rig:	CME-45
Drilling Company:	Empire Soils Investigations, Inc.
Date Drilled:	April 20, 1990
Plugging Material:	Grout

Split Spoons

Split Spoon No.	Depth	Blow Counts	Hammer	Recovery
1	1.0 - 3.0' bgs	12, 8, 10, 10	140 lb	16"
2	3.0 - 5.0' bgs	12, 7, 8, 7	140 lb	12"
3	5.0 - 7.0' bgs	4, 4, 7, 8	140 lb	18"
4	7.0 - 9.0' bgs	10, 12, 17, 19	140 lb	24"
5	9.0 - 11.0' bgs	0, 10, 11, 13	140 lb	22"

Samples Collected

Sample ID No.	Date	Analyses	Depth
609A-1008-SB01	4/20/90	TPHC, PCB	1.0 - 1.5'
609A-1008-SB02	4/20/90	TPHC, PCB	5.5 - 6.0'
609A-1008-SB03	4/20/90	TPHC, PCB	10.0 - 10.5'

Boring No. 1009

Geologic Log

0.0 - 1.5'	Open trench
1.5 - 2.0'	Concrete lining
2.0 - 2.1'	Brown fine sand fill, discolored
2.1 - 4.8'	Gray silt with minor clay and fine sand, moist
4.8 - 8.0'	Light gray and orange-brown mottled, very fine silty sand

Drilling Specifications

Drilling Method:	Continuous split spoon
Rig:	Mobil B-61
Drilling Company:	J.E. Fritts & Associates, Inc.
Date Drilled:	October 9, 1990
Plugging Material:	Cuttings

Split Spoons

Split Spoon No.	Depth	Blow Counts	Hammer	Recovery
1	2.0 - 4.0' bgs	8, 5, 6, 6	140 lb	10"
2	4.0 - 6.0' bgs	8, 12, 15, 11	140 lb	18"
3	6.0 - 8.0' bgs	11, 8, 5, 5	140 lb	18"

Samples Collected

Sample ID No.	Date	Analyses	Depth
609A-1009-SB01	10/9/90	TPHC, PCB	2.0 - 2.5'
609A-1009-SB02	10/9/90	TPHC, PCB	5.5 - 6.0'
609A-1009-SB03	10/9/90	TPHC, PCB	7.5 - 8.0'

Boring No. 1010

Geologic Log

0.0 - 2.2'	Open trench
2.2 - 2.7'	Concrete lining
2.7 - 3.8'	Coarse orange-brown gravelly sand, chemical odor
3.8 - 7.3'	Greenish-gray silty clay with vegetative matter grading to dark orange-brown at 5 feet
7.3 - 8.5'	Dense gray-brown clayey silt with small roots

Drilling Specifications

Drilling Method:	Continuous split spoon
Rig:	Mobil B-61
Drilling Company:	J.E. Fritts & Associates, Inc.
Date Drilled:	October 9, 1990
Plugging Material:	Cuttings

Split Spoons

Split Spoon No.	Depth	Blow Counts	Hammer	Recovery
1	2.5 - 4.0' bgs	27, 21, 13	140 lb	18"
2	4.5 - 6.5' bgs	8, 10, 11, 10	140 lb	24"
3	6.5 - 8.5' bgs	8, 5, 6, 6	140 lb	24"

Samples Collected

Sample ID No.	Date	Analyses	Depth
609A-1010-SB01	10/9/90	TPHC, PCB, VOC+15, As, Cd, phenols	2.5 - 3.0'
609A-1010-SB02	10/9/90	TPHC, PCB	6.0 - 6.5'
609A-1010-SB03	10/9/90	TPHC, PCB	8.0 - 8.5'

Polychrome, Yardville, NJ

Boring No. 1011

Geologic Log

0.0 - 3.5'	Open trench
3.5 - 4.0'	Concrete lining
4.0 - 5.2'	Medium to coarse orange-brown gravelly sand, moist, with chemical odor
5.2 - 8.5'	Greenish-gray clayey silt grading to orange-brown and gray mottled clayey silt
8.5 - 9.5'	Gray-brown clayey silt, wet

Drilling Specifications

Drilling Method:	Continuous split spoon
Rig:	Mobil B-61
Drilling Company:	J.E. Fritts & Associates, Inc.
Date Drilled:	October 9, 1990
Plugging Material:	Cuttings

Split Spoons

Split Spoon No.	Depth	Blow Counts	Hammer	Recovery
1	4.0 - 5.5' bgs	18, 12, 20	140 lb	18"
2	5.5 - 7.5' bgs	10, 11, 10, 11	140 lb	24"
3	7.5 - 9.5' bgs	4, 3, 4, 5	140 lb	16"

Samples Collected

Sample ID No.	Date	Analyses	Depth
609A-1011-SB01	10/9/90	TPHC, PCB, VOC+15, As, Cd, phenols	4.0 - 4.5'
609A-1011-SB02	10/9/90	TPHC, PCB	6.0 - 6.5'
609A-1011-SB03	10/9/90	TPHC, PCB	8.0 - 8.5'

609A:PAA008DA.W51

ENVIRON
BORING/WELL LOG

BORING/WELL#: MW05
PERMIT#: 28-26385-5
DATE: September 8, 1990
LOGGED BY: Eric Oelkers
DRILLING CO.: J.E.Fritts & Associates, Inc.
DRILLER: Robert Maier
RIG: Mobile Drill B-61
METHOD: Hollow-Stem Auger
BORING DIA.: 8 Inches
BORING DEPTH: 15 Feet
DEPTH TO WATER: 11 Feet
SURFACE ELEV.: 63.75

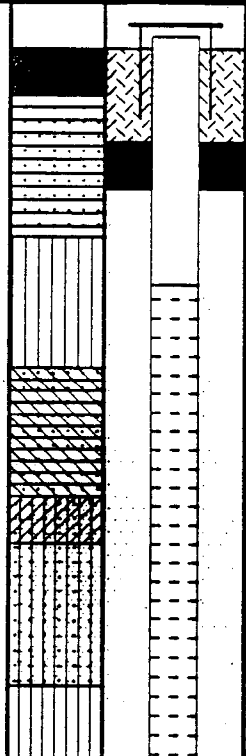
WELL CASING
LENGTH: 5 Feet
DIA.: 4 inches
TYPE: Schedule 40 PVC
T.O.C. ELEV.: 63.58

WELL SCREEN
LENGTH: 10 Feet
DIA.: 4 Inches
SLOT SIZE: No. 10

WELL DEVELOPMENT
TIME: 1 Hour
METHOD: Pump
EST. YIELD: 1 gpm

PROJECT: Polychrome
Yardville, NJ
CASE #: 02-0609A

COMMENTS:



DEPTH (feet)	SAMPLE TYPE	BLOW COUNTS	SAMPLE INTERVAL (feet)	DESCRIPTIVE INTERVAL (feet)	DESCRIPTION
0				0.0–1.0	Asphalt Underlain by Trap Rock
				1.0–4.0	Brown Silty Sand, Some Gravel, Moist
5	X	5-6 2-3	5.0–7.0	4.0–6.7	Light Gray Silt and Fine Sand, Moist
	X	4-3 6-7	8.0–10.0	6.7–9.5	Light Brown Silt with Fine Sand and Clay, Some Gravel, Moist
10				9.5–10.5	Brown Clayey Silt with Fine Sand and Gravel, Very Moist/Wet
	X	3-8 7-9	10.0–12.0	10.5–13.5	Brown Silt and Fine Sand with some Gravel, Moist
	X	5-5 8-9	13.0–15.0	13.5–15.0	Dark Gray Compact Silt, Moist
15					
20					

BORING/WELL# MW06

PERMIT# 28-26386-3

DATE: September 8, 1990

LOGGED BY: Eric Oelkers

DRILLING CO: J.E.Fritts & Associates, Inc.

DRILLER: Robert Maier

RIG: Mobile Drill B-61

METHOD: Hollow-Stem Auger

BORING DIA.: 8 Inches

BORING DEPTH: 10 Feet

DEPTH TO WATER: 7.7 Feet

SURFACE ELEV.: 61.30

WELL CASING

LENGTH: 4.5 Feet

DIA.: 4 Inches

TYPE: Schedule 40 PVC

T.O.C. ELEV.: 63.39

WELL SCREEN

LENGTH: 5 Feet

DIA.: 4 Inches

SLOT SIZE: No. 10

WELL DEVELOPMENT

TIME: 1 Hour

METHOD: Bailing

EST. YIELD: <1 gpm

ENVIRON

BORING/WELL LOG

PROJECT: Polychrome

Yardville, NJ

CASE # 02-0609A

COMMENTS:

06

DEPTH (feet)	GRAPHIC LOG	WELL CONSTRUCT	SAMPLE TYPE	BLOW COUNTS	SAMPLE INTERVAL (feet)	DESCRIPTIVE INTERVAL (feet)	DESCRIPTION
0						0.0–3.0	Light Brown Silty Fine Sand with Some Gravel, Moist
						3.0–6.0	Brown Sand and Gravel, Moist
5			X	10–12 25–16	5.0–7.0		
			X	3–3 3–3	8.0–10.0	6.0–9.3	Brown Sand and Silt with Some Gravel, Moist
10						9.3–10.0	Mottled Brown/Dark Gray Compact Silt, Moist
15							
20							

MONITORING WELL CERTIFICATION - FORM A - AS-BUILT CERTIFICATION
(One form must be completed for each well)

Name of Permittee:	Polychrome Corporation
Name of Facility:	Polychrome Corporation
Location:	584 Route 130, Yardville, Mercer County NJ 08691
NJPDES Permit No.:	NA

CERTIFICATION

Well Permit Number (As assigned by NJDEP's Well Drilling Permits Section (609-984-6831):	28 - 26385 - 5
Owner's Well Number (As shown on the application or plans):	MW5
Well Completion Date:	10/8/90
Distance from Top of Casing (cap off) to Ground Surface (one-hundredth of a foot):	2.06
Total Depth of Well (one-hundredth of a foot):	14.21
Depth to Top of Screen from Top of Casing (one-hundredth of a foot):	4.21
Screen length (feet):	10
Screen or Slot Size:	No. 10 slot
Screen or Slot Material:	PVC
Casing Material (PVC, Steel or Other-Specify):	PVC
Casing Diameter (inches):	4
Static Water Level from Top of Casing at the Time of Installation (one-hundredth of a foot):	7.71
Yield (gallons per minute):	< 1
Length of Time Well Pumped or Bailed	1 Hour
Lithologic Log:	Attach

AUTHENTICATION

I certify under penalty of law that, where applicable, I meet the requirements as specified on the reverse of this page, that I have personally examined and am familiar with the information submitted in this document and all attachments, and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe the submitted information is true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

Robert Maier
Name (Type or Print)

Robert M Maier
Signature

J1470
Certification or License No.

SEAL

Certification by Executive Officer or Duly Authorized Representative

William D. Kraft
Name (Type of Print)

William D. Kraft
Signature

Associate Geologist
Title

11/16/90
Date

609A:PAA00814.W51

THIS FORM MUST BE COMPLETED BY THE PERMITTEE OR HIS/HER AGENT

GROUND WATER MONITORING WELL CERTIFICATION-FORM B-LOCATION CERTIFICATION

Name of Permittee: Polychrome Corporation
Name of Facility: Polychrome Corporation
Location: 584 Route 130, Yardville, NJ 08691
NJPDES Permit No: N/A

LAND SURVEYOR'S CERTIFICATION

Well Permit Number (As assigned by NJDEP's Water Allocation Section, (609-984-6831): This number must be permanently affixed to the well casing. 28-26385-5

Longitude (one-tenth of a second): West 74°39'18.726"
Latitude (one tenth of a second): North 40°11'19.381"
Elevation of Top of Casing (cap off) (one-hundredth of a foot): 63.58
Owner's Well Number (As shown on the application or plans): MW-5

AUTHENTICATION

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments, and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe the submitted information is true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

James M. Stewart

PROFESSIONAL LAND SURVEYOR'S SIGNATURE

SEAL

James M. Stewart

PROFESSIONAL LAND SURVEYOR'S NAME
(Please print or type)

26108

PROFESSIONAL LAND SURVEYOR'S LICENSE

The Department reserves the right in cases of violation of permit specified ground water limits or Ground Water Quality Standards (N.J.A.C. 7:9-6.1 et seq.) to require that wells be resurveyed to an accuracy of one-hundredth of a second latitude and longitude. This shall not be considered to be a major modification of the NJPDES permit.

MONITORING WELL CERTIFICATION - FORM A - AS-BUILT CERTIFICATION
(One form must be completed for each well)

Name of Permittee:	Polychrome Corporation
Name of Facility:	Polychrome Corporation
Location:	584 Route 130, Yardville, Mercer County NJ 08691
NJPDES Permit No.:	NA

CERTIFICATION

Well Permit Number (As assigned by NJDEP's Well Drilling Permits Section (609-984-6831):	28-26386-3
Owner's Well Number (As shown on the application or plans):	MW6
Well Completion Date:	10/8/90
Distance from Top of Casing (cap off) to Ground Surface (one-hundredth of a foot):	3.27
Total Depth of Well (one-hundredth of a foot):	12.17
Depth to Top of Screen from Top of Casing (one-hundredth of a foot):	7.17
Screen length (feet):	5
Screen or Slot Size:	No. 10 slot
Screen or Slot Material:	PVC
Casing Material (PVC, Steel or Other-Specify):	PVC
Casing Diameter (inches):	4
Static Water Level from Top of Casing at the Time of Installation (one-hundredth of a foot):	10.40
Yield (gallons per minute):	< 1
Length of Time Well Pumped or Bailed	1 Hour
Lithologic Log:	Attach

AUTHENTICATION

I certify under penalty of law that, where applicable, I meet the requirements as specified on the reverse of this page, that I have personally examined and am familiar with the information submitted in this document and all attachments, and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe the submitted information is true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

Robert Maier
Name (Type or Print)

Robert M. Maier
Signature

J1470
Certification or License No.

SEAL

Certification by Executive Officer or Duly Authorized Representative

William O. Kraft
Name (Type of Print)

William O. Kraft
Signature

Associate Geologist
Title

11/16/90
Date

609A:PAA00814.W51

THIS FORM MUST BE COMPLETED BY THE PERMITTEE OR HIS/HER AGENT

GROUND WATER MONITORING WELL CERTIFICATION-FORM B-LOCATION CERTIFICATION

Name of Permittee: Polychrome Corporation
Name of Facility: same
Location: 584 Route 130, Yardville, NJ 08691
NJPDES Permit No: N/A

LAND SURVEYOR'S CERTIFICATION
Well Permit Number (As assigned by NJDEP's Water Allocation Section, (609-984-6831): This number must be permanently affixed to the well casing. 28-26386-3

Longitude (one-tenth of a second): West 74°39'18.372"
Latitude (one tenth of a second): North 40°11'23.737"
Elevation of Top of Casing (cap off) (one-hundredth of a foot): 63.89
Owner's Well Number (As shown on the application or plans): MW-6

AUTHENTICATION
I certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments, and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe the submitted information is true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

James M. Stewart
PROFESSIONAL LAND SURVEYOR'S SIGNATURE

SEAL

James M. Stewart
PROFESSIONAL LAND SURVEYOR'S NAME
(Please print or type)

26108
PROFESSIONAL LAND SURVEYOR'S LICENSE

The Department reserves the right in cases of violation of permit specified ground water limits or Ground Water Quality Standards (N.J.A.C. 7:9-6.1 et seq.) to require that wells be resurveyed to an accuracy of one-hundredth of a second latitude and longitude. This shall not be considered to be a major modification of the NJPDES permit.

7065A/020190

ATTACHMENT 2

GROUND-WATER ELEVATIONS AND ANALYSIS OF FLOW

(Information Provided by Ms. Carol Surgens of Jones, Day, Reavis & Pogue to Roux Associates, Inc. on June 11, 1991)

ATTACHMENT 2

Carol Surgens, Esq., counsel for Polychrome, informed ENVIRON of the verbal comments she received from Ms. Sharon Bruder, NJDEP Case Manager, regarding ENVIRON's characterization of ground water flow in its November 1990 Phase III results report for Polychrome's former Yardville facility. Specifically, NJDEP required three additional rounds of ground water elevation data for the site to 1) confirm that MW5 monitors ground water quality downgradient of the interior trench in AEC 10, and 2) confirm that MW6 is downgradient of MW4. These elevation measurements were to be taken no less than two weeks apart and were to be plotted and contoured before submission to NJDEP. The analysis and interpretation of these ground water elevation data and this attachment were prepared with the assistance of Dr. M. Farrukh Mohsen, a Senior Science Advisor with ENVIRON. Dr. Mohsen has extensive experience in the development and application of numerical models to simulate contaminant transport in ground water.

ENVIRON collected three sets of elevation measurements on January 22, February 5 and February 19, 1991 as provided on Table 1. These three rounds of elevations in general confirm that ground water flow is to the northeast. However, these measurements also indicate that the elevation at MW5 is anomalously low, consistent with the October and November 1990 elevations measurements presented in the November 1990 results report. In order to assess the extent and impact of this apparent anomaly, ENVIRON analyzed the ground water elevation data using FEPER, an ENVIRON-developed finite element perspective program. The attached figures provide the ground water elevations at each of the six monitoring wells and linearly interpolated elevation contours over triangles as derived from FEPER. As the figures indicate, the regional ground water flow generally is to northeast with a localized area of more easterly flow adjacent to the building.

ENVIRON submits that this apparent flow anomaly is caused by low recharge in the vicinity of MW5 because this well is installed adjacent to the building and in the main paved parking area. No other well at this site is installed through pavement. The pavement near MW5 prevents direct recharge to ground water from rainstorm events resulting in ground water elevations at MW5 lower than anticipated based on the northeastern regional ground water flow. This results in an area of easterly flow as indicated on the attached figures. Since the ground water elevations at MW5 are consistently lower than would be expected, ENVIRON believes that the data support the above conclusion.

TABLE 1 Ground Water Elevations (above mean sea level)			
	Date and Elevation		
Monitoring Well	**January 22**	**February 5**	**February 19**
MW1	59.58	59.77	59.81
MW2	61.34	60.99	60.89
MW3	60.04	60.03	59.91
MW4	58.43	57.69	57.36
MW5	57.14	56.98	56.70
MW6	57.27	56.45	56.12

ENVIRON also submits that these ground water elevations demonstrate that MW5 does monitor ground water quality downgradient of the interior trench. The flow variation discussed above does not affect ground water flow beneath the trench; ground water flow in this area is to the northeast, the regional flow direction. Thus, MW5 monitors ground water migrating from beneath the trench. ENVIRON's analysis of ground water flow also confirms that MW6 is downgradient of MW4. Ground water flow in this portion of the site is in the regional northeast direction.

These elevation data support ENVIRON's conclusions in the November 1990 Phase III results report with respect to the distribution of VOCs in groundwater at this site. Minimal VOC concentrations were detected at MW5, which these elevation data demonstrate monitors ground water quality downgradient of AEC 10. Accordingly, ENVIRON submits that VOC data from MW5 sufficiently characterize ground water quality downgradient of AEC 10, further supporting ENVIRON's previous conclusion that the soils beneath the interior trench have not resulted in significant ground water contamination, as stated in the November 1990 results report.

Additionally, the elevation data are consistent with the conclusion, as stated in the November 1990 results report, that the source of VOCs at MWs 4 and 6 is most likely AEC 2, the former site of a spill of solvent-contaminated absorbent material during Monsanto Company's ownership of the facility. ENVIRON remediated this area in January 1990. Furthermore, VOCs detected at MW4 likely have not migrated off-site given the substantial decrease in VOC concentrations from MW4 to MW6 and ground water flow from MW4 to MW6.

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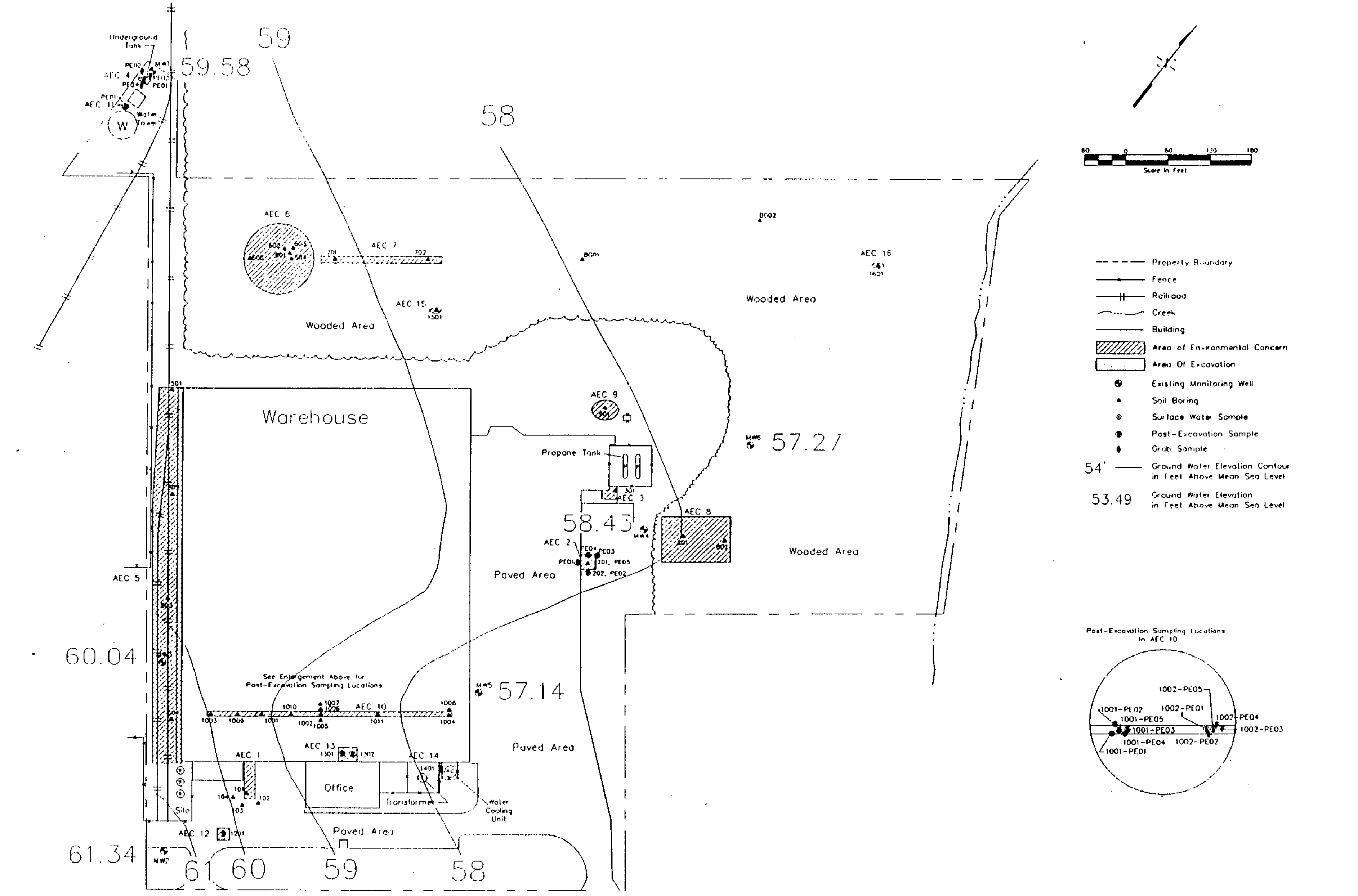
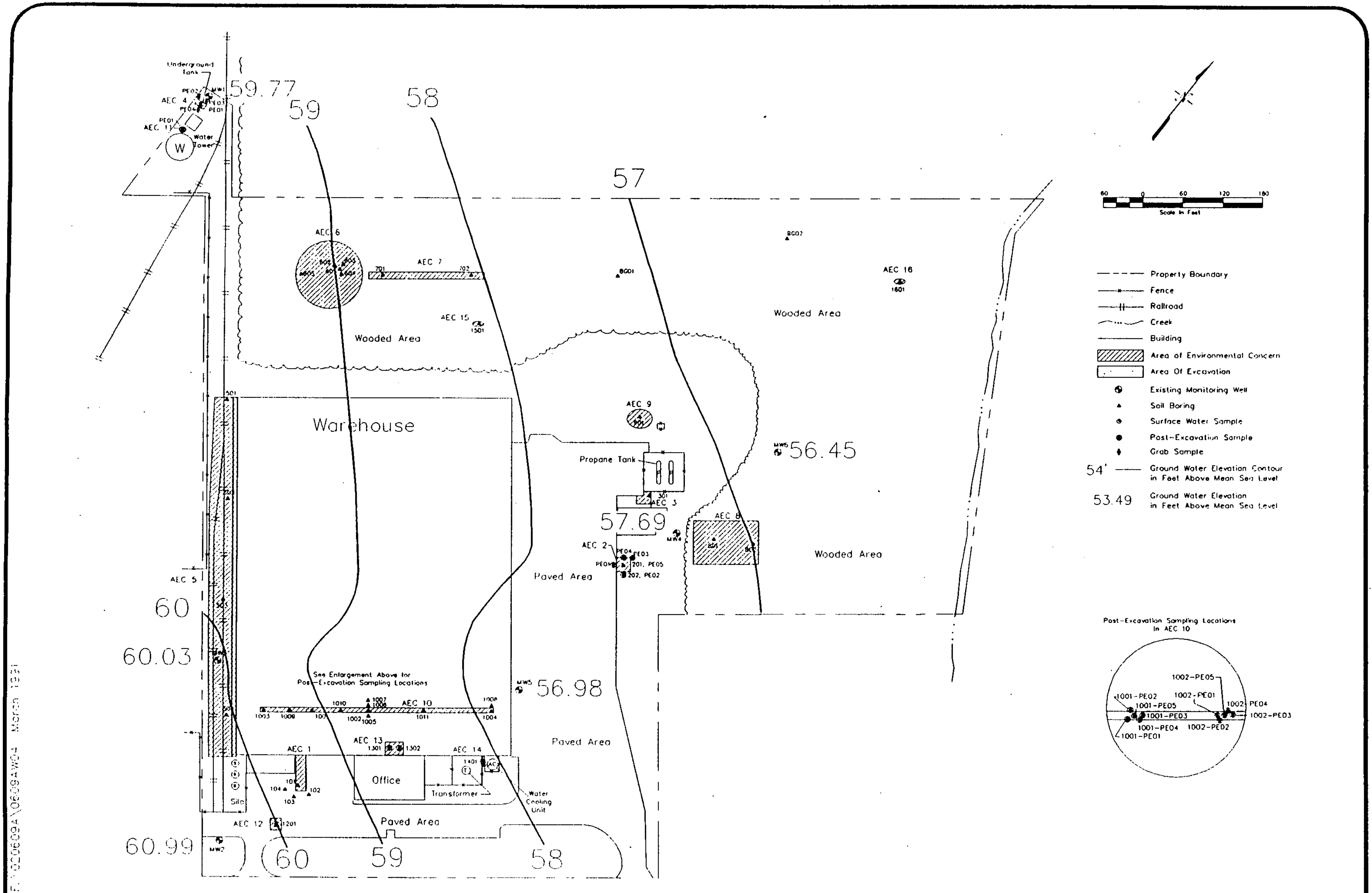


ENVIRON
Counsel in Health and Environmental Science

JANUARY 22, 1991 GROUND WATER ELEVATIONS AND CONTOURS
POLYCHROME CORPORATION
Yardville, New Jersey

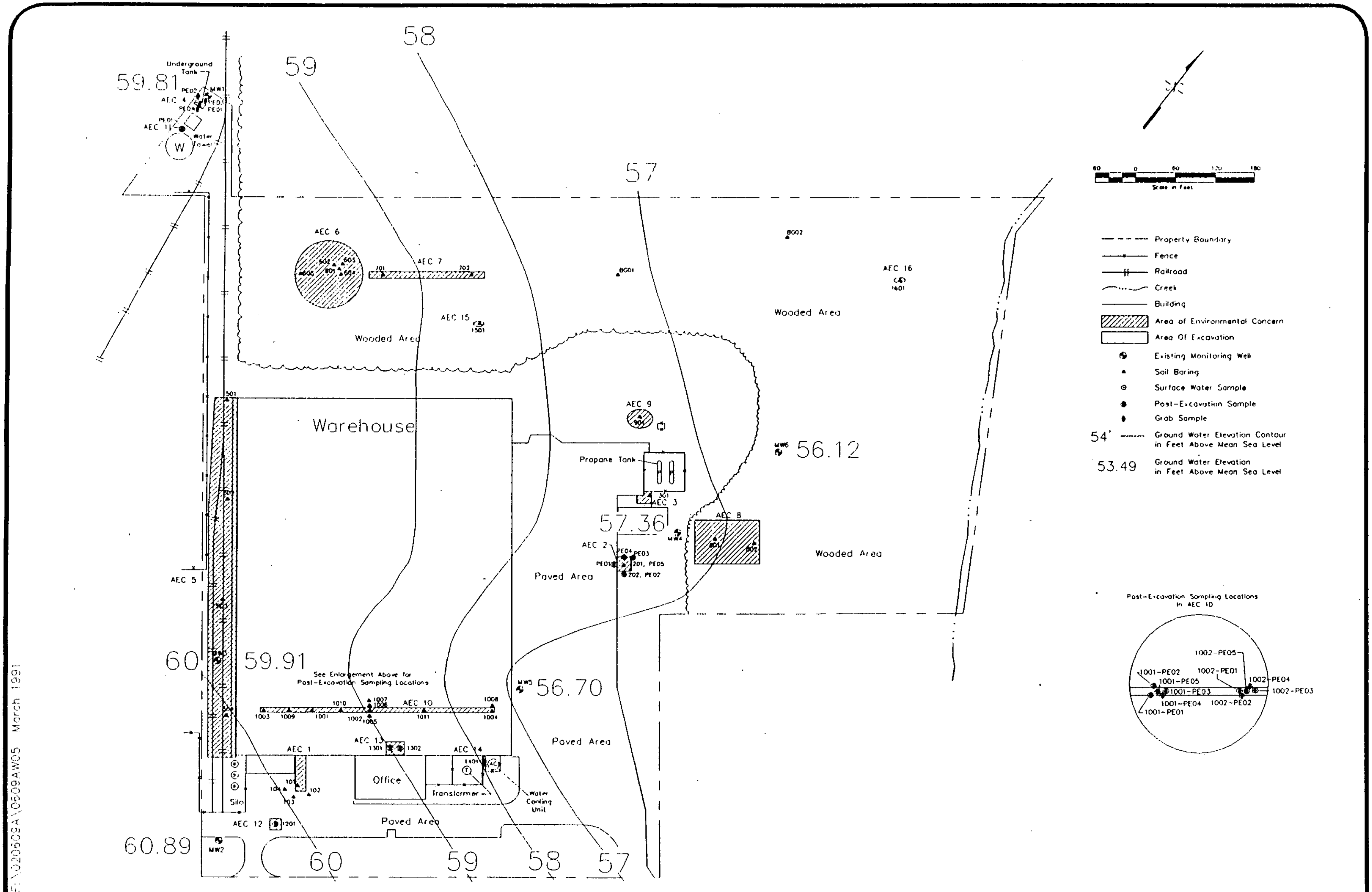
Figure 1



ENVIRON
Counsel in Health and Environmental Science

FEBRUARY 5, 1991 GROUND WATER ELEVATIONS AND CONTOURS
POLYCHROME CORPORATION
Yardville, New Jersey

Figure 2



ENVIRON
Counsel in Health and Environmental Science

FEBRUARY 19, 1991 GROUND WATER ELEVATIONS AND CONTOURS
POLYCHROME CORPORATION
Yardville, New Jersey

Figure 3

ATTACHMENT 3

SITE HISTORY BETWEEN 1961 AND 1982

(Provided by Ms. Jo Hanson of
Monsanto Company to Roux Associates, Inc.)

POLYCHROME FACILITY
YARDVILLE, NEW JERSEY
Site History

This history covers only the years 1961 to 1982. For information about activities at the site after early 1982, contact Polychrome.

Mahony-Troast Construction Company owned several acres of undeveloped land in the Yardville area. In 1961, Plax Corporation purchased 16.4 acres from Mahony-Troast, who constructed the existing building for Plax. Plax made plastic bottles by blow molding. Monsanto was a minority stockholder in Plax.

In 1962, Monsanto bought out the remaining stock of Plax and continued to run the bottle-blowing operation at Yardville. In 1965, Monsanto bought an additional 7.34 acres from Mahony-Troast. Also, sometime in the mid 1960s, the existing building was expanded to make room for additional blow-molding equipment. In 1976, an additional 0.41 acre was purchased from Mahony-Troast. (The legal description of these three tracts is attached.) In 1981, the equipment at Yardville was removed. The land and buildings were sold to Polychrome in early 1982.

The process for blowing plastic bottles was not a chemical operation. Plastic pellets were received from outside manufacturers in railcars (occasionally by truck) and blown into silos for storage. From the silos, the pellets were transferred to the feed hoppers, through grinders and into the extruders. Electric heat and the mechanical energy and pressure of the extrusion process melted the pellets. The melted plastic was extruded into molds and blown with air to the shape of the mold.

After being removed from the molds, the bottles were trimmed of excess plastic, run through an open flame, packed in cartons, and palletized for shipment. The flame treatment was needed to make glue and/or ink stick to the surface. The flames were provided by individual natural gas units at each production line. Propane was used as a backup in cold weather (the facility had an interruptible service contract with the gas utility) or other times when there was an interruption in natural gas service. The bottles were air cooled.

Bottles were made in a variety of shapes and sizes. Some examples of familiar products that they were used for are quart, half-gallon, and gallon Clorox, Lux Dishwashing Liquid, and Aunt Jemima Pancake Syrup. At times, there were also some lines which made smaller bottles (such as pill bottles) by injection molding.

Except for a short time in the late 1960s when a small silk-screening process was operated, no labels were printed or glued onto the bottles at this facility.

The bottle-blowing and injection molding processes used no liquid chemicals. If required, colors were added to the bottles by mixing pellets which contained concentrated colors into the mixers at the beginning of the process. When the mixed pellets were ground and melted in the extruders, the colors blended to the desired shades. The concentrated color pellets were prepared by outside vendors. Dry powders were also occasionally added to the blends as slip agents.

The process equipment used hydraulic fluids in the extruders and mold heads. Various lubricants were also used in the turn tables, conveyors, forks lifts, and other equipment.

From 1961 until 1965, the plant disposed of used machine oil by putting it on the railroad tracks to control weeds. In 1965, the ballast under the tracks was removed to a depth of 18" and replaced with clean ballast. After 1965, used oil was collected in a tank outside the maintenance shop and sold to reclaimers. A small amount of oil continued to find its way to the tracks until 1973. In early 1973, all oil flow to the tracks was stopped and the oil stained ballast was replaced with new ballast.

Cooling water was pumped to the extruders from a cooling tower outside the building and returned to a hot well through piping in the trench which runs across one end of the building.

The maintenance shop used solvents for cleaning machine parts. Small quantities of solvents were also used in the quality control lab for wiping the surfaces of the bottles to test adhesion properties and for other quality checks. Solvents were used as carriers for the inks during the short period when the silk-screening process was operated.

Changes were often made in the equipment. When a new size or shape of bottle was made, the extruder heads, molds, and much of the down-stream handling equipment had to be changed. Some runs of a particular bottle lasted for many months or years, *e.g.*, Clorox bottles. Other runs were as short as a few hours. As newer, bigger, or better equipment came on the market, whole machines and/or lines were replaced. A rough sketch showing a typical layout of the process is attached.

EXHIBIT A

THIS INDENTURE, made this 24 day of February in the year of our Lord one thousand nine hundred and eighty-two BETWEEN MONSANTO COMPANY, a Delaware Corporation (herein called the "Grantor"), with an office at St. Louis, Missouri, party of the first part, and POLYCHROME CORPORATION, a New York Corporation (herein called the "Grantee"), with an office at 137 Alexander Street, Yonkers, New York 10702, party of the second part.

WITNESSETH, That the Grantor for and in consideration of the sum of

lawful money of the United States of America, well and truly paid by the Grantee to the Grantor, at and before the ensealing and delivery of these presents, the receipt whereof is hereby acknowledged, has granted, bargained, sold, aliened, enfeoffed, released, conveyed and confirmed, and by these presents does grant, bargain, sell, alien, enfeoff, release, convey and confirm, unto the Grantee, its successors and assigns

ALL THOSE CERTAIN tracts or parcels of land situated in the Township of Hamilt County of Mercer and State of New Jersey, being known as Tax Block Number 598, Lots Numbered 41 and 44, and being more particularly described as follows:

TRACT NO. 1

BEGINNING at a point in the northerly line of the Yardville-Robbinsville Road, U.S. Route 130 (126 feet wide), said point being marked by a concrete monument at the southwesterly corner of lands of Edna Cleary, and running thence

(1) along the northerly line of U. S. Route 130 South 60 degrees 48 minutes 40 seconds West a distance of 690.00 feet to a point, thence

(2) North 29 degrees 11 minutes 20 seconds West along lands remaining to Mahony-Troast Construction Company a distance of 1,035.00 feet to a point, thence

(3) North 60 degrees 48 minutes 40 seconds East along lands remaining to Mahony-Troast Construction Company a distance of 690.00 feet to a point, thence

(4) South 29 degrees 11 minutes 20 seconds East in part along lands remaining to Mahony-Troast Construction Company and in part along lands of Edna Cleary a distance of 1,035.00 feet to the point and place of BEGINNING.

Containing 16.395 acres of land.

The foregoing description is in accordance with a survey prepared by Thomas Tyler Moore, N.J.P.E. & L.S. No. 9517, dated May 8, 1961.

Being the premises conveyed to Flax Corporation by Mahony-Troast Construction Company by deed dated May 19, 1961 and recorded in the Office of the Clerk of Mercer County on May 25, 1961, in Book 1577 of Deeds for said County, page 584.

SUBJECT TO (i) slope and drainage rights granted to the State of New Jersey by deed recorded in Book 688, Page 362 and (ii) any rights of way for public roads.

TRACT NO. 2

ALL THAT CERTAIN tract or parcel of land situate in the Township of Hamilton, County of Mercer and State of New Jersey, being more particularly described as follows:

BEGINNING at a point in the northeasterly line of lands conveyed by MAHONY-TROAST CONSTURCTION COMPANY to PLAX CORPORATION by deed dated May 19, 1961, recorded in the Mercer County Clerk's office in deed book 1577 at page 584, said Beginning point being 400.00 feet N. 29° 11' 20" West of the northwesterly line of the Yardville-Robbinsville Rd. (U.S. Route No. 130), and running; thence,

(1) Along said northeasterly line of lands now or formerly of Plax Corporation N. 29° 11' 20" West 635.00 feet to the northeasterly corner of said lands now or formerly of Plax Corporation; thence,

(2) Through lands of the Grantor N. 60° 48' 40" East 578.16 feet to a point in the Grantors easterly line and lands now or formerly of Ettore Poli; thence,

(3) South 9° 01' 40" West 69.25 feet along the Grantors easterly line to a point in said easterly line; thence,

(4) South 21° 34' 20" East 585.89 feet along the Grantor's easterly line to lands now or formerly of Edna Cleary; thence,

(5) South 60° 48' 40" West 457.50 feet to lands now or formerly of Plax Corporation and the point and place of Beginning.

Being 7.34 acres of land.

Being the premises conveyed to Monsanto Company by Mahony-Troast & Construction Company by deed dated March 12, 1965, recorded, March 17, 1965 in the Mercer County Clerk's Office in Deed Book 1728 at page 890.

Being the 7.34 acres shown on a survey by Myron X. Feld N.J.P.E. & L.S. #6408 dated January 15, 1965, No. 12399-A, and titled "Survey of Premises of Mahony-Troast Construction Company Boundary Line and Between Those Premises and Lands Owned by Ettore Poli, in The Township of Hamilton, County of Mercer, State of New Jersey."

SUBJECT TO statutory and common law flooding and drainage rights, if any, in Back Creek.

TRACT NO. 3

BEGINNING at a point, said point being the northwesterly corner of lands of Georgia Pacific Corporation and from said BEGINNING point, running thence;

(1) Through lands of Mahony-Troast Construction Company, along the northerly prolongation of the westerly line of lands of the aforementioned Georgia Pacific Corporation, North 06 degrees 14 minutes 20 seconds East, 228.00 feet to a point, thence;

(2) Continuing through lands of said Mahony-Troast Company, the following two courses: South 83 degrees 45 minutes 40 seconds East, 40.00 feet to a point, thence;

(3) South 29 degrees 11 minutes 20 seconds East, 162.60 feet to a point, in the northwesterly line of lands of Monsanto Company, thence;

(4) Along the last mentioned lands, and along the northwesterly line of lands of the aforementioned Georgia Pacific Corporation, South 60 degrees 48 minutes 40 seconds West, 164.76 feet to the point and place of BEGINNING.

Containing 0.412 acres.

BEING the premises conveyed to Monsanto Company by Mahony-Troast Construction Company by deed dated June 22, 1976 recorded November 5, 1976 in the Mercer County Clerk's office in Volumne 2029, Page 378.

The above-described Tract No. 3 is subject to the following easements:

(1) A proposed 20-foot wide drainage easement the centerline of which is more particularly described as follows:

BEGINNING at a point in the northerly line of lands of Georgia-Pacific Corporation, said point bearing along said northerly line, South 60 degrees 48 minutes 40 seconds West, 52.25 feet from the northeasterly corner of said lands of Georgia-Pacific Corporation, and running thence;

Through the above-described premies, North 30 degrees 58 minutes 40 seconds East 104.85 feet to a point in a westerly line of lands of Mahony-Troast Construction Company, said point bearing along said line, North 29 degrees 11 minutes 20 seconds West 52.16 feet from a point and corner of the last mentioned lands; and

(2) A proposed 15-foot wide easement for a railroad siding the centerline of which is more particularly described as follows:

BEGINNING at a point in the northerly line of lands of Georgia-Pacific Corporation, said point bearing along said northerly line, South 60 degrees 48 minutes 40 seconds West 7.76 feet from the northeasterly corner of said lands of Georgia-Pacific Corporation and running thence;

Through the above-described premises, North 14 degrees 40 minutes 20 seconds West 170.7 feet to a point in a southerly line of lands of Mahony-Troast Construction Company, said point bearing along said line North 83 degrees 45 minutes 40 seconds West 4.5 feet from a point and corner of the last mentioned lands.

SUBJECT TO any liens for real estate taxes and assessments not yet due and payable, to any state of facts which a correct survey or inspection of the premises would show and to zoning.

TO HAVE AND TO HOLD the said estate, right, title and interest, if any, of the Grantor in said land and premises unto the Grantee, its successors and assigns forever

IN WITNESS WHEREOF, the Grantor has caused its corporate seal to be hereto affixed and these presents to be duly executed by its proper officers the day and year first above written.

MONSANTO COMPANY

By John W. Hanley
John W. Hanley
Chief Executive Officer

Attest: J. R. Bley, Jr.
(J. R. Bley, Jr.)
Assistant Secretary

STATE OF MISSOURI)
SS.:
COUNTY OF ST. LOUIS)

BE IT REMEMBERED, THAT ON THIS 24 DAY OF February 1982, before me, the subscriber, a Notary Public, personally appeared John W. Hanley, the Chief Executive Officer of MONSANTO COMPANY, who, I am satisfied, is the person who executed the foregoing instrument on behalf of said corporation, and he thereupon acknowledged that he signed, sealed with the corporate seal and delivered said instrument as such officer and that said instrument is the voluntary act and deed of said corporation, made by virtue of authority from its Board of Directors, and that the full and actual consideration paid or to be paid for the transfer of title to the realty evidenced by the within deed as such consideration is defined in P.L. 1968 c.49, Sec. 1(c) is $3,475,000.00.

( )
A Notary Public of St. Louis County, Missouri
My Commission Expires:

JEAN C. MUENZ
NOTARY PUBLIC STATE OF MISSOURI
ST. LOUIS CO.
MY COMMISSION EXPIRES APR 30 1983

Prepared by
Roy G. Cooper
Roy G. Cooper

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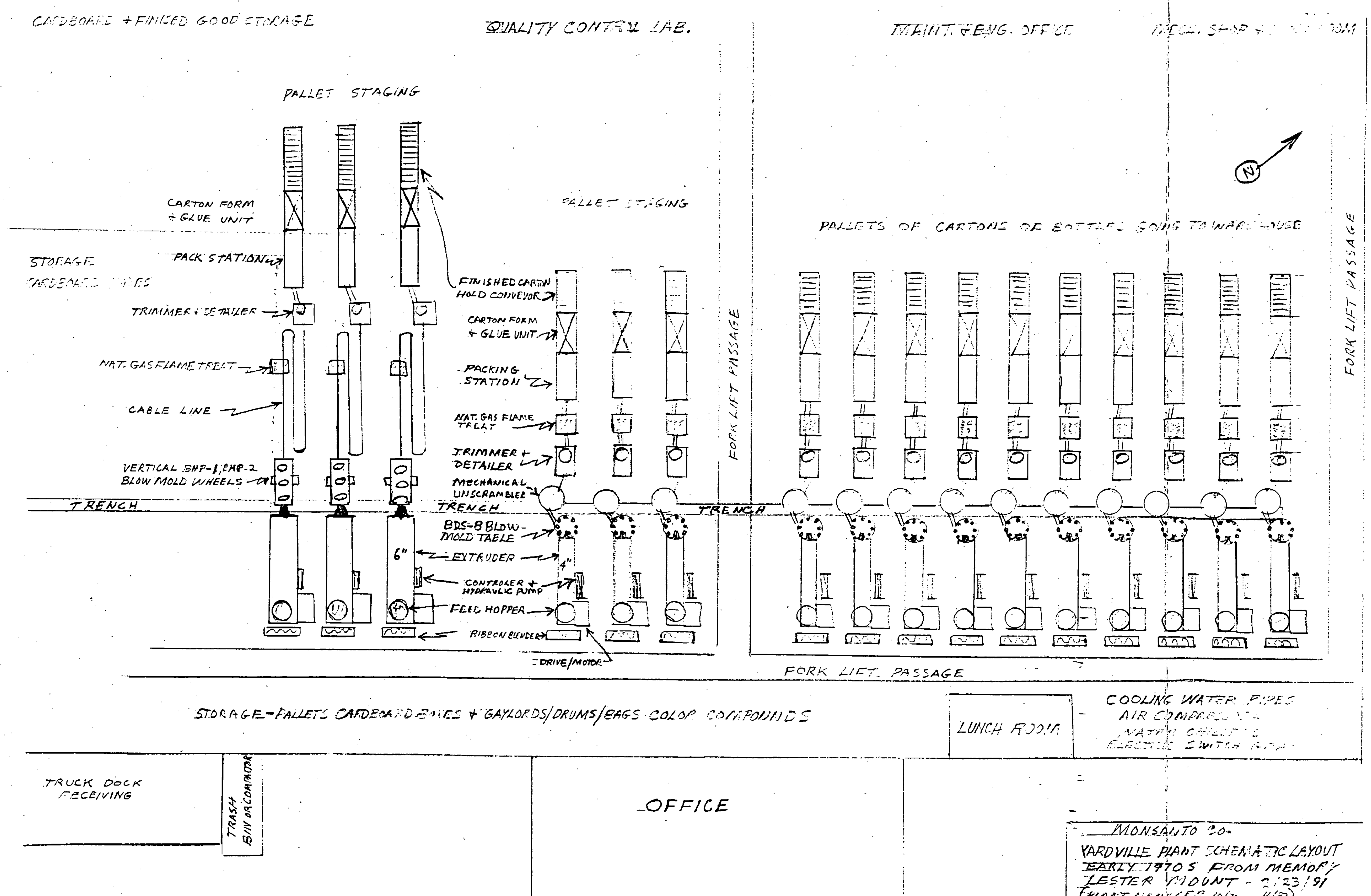
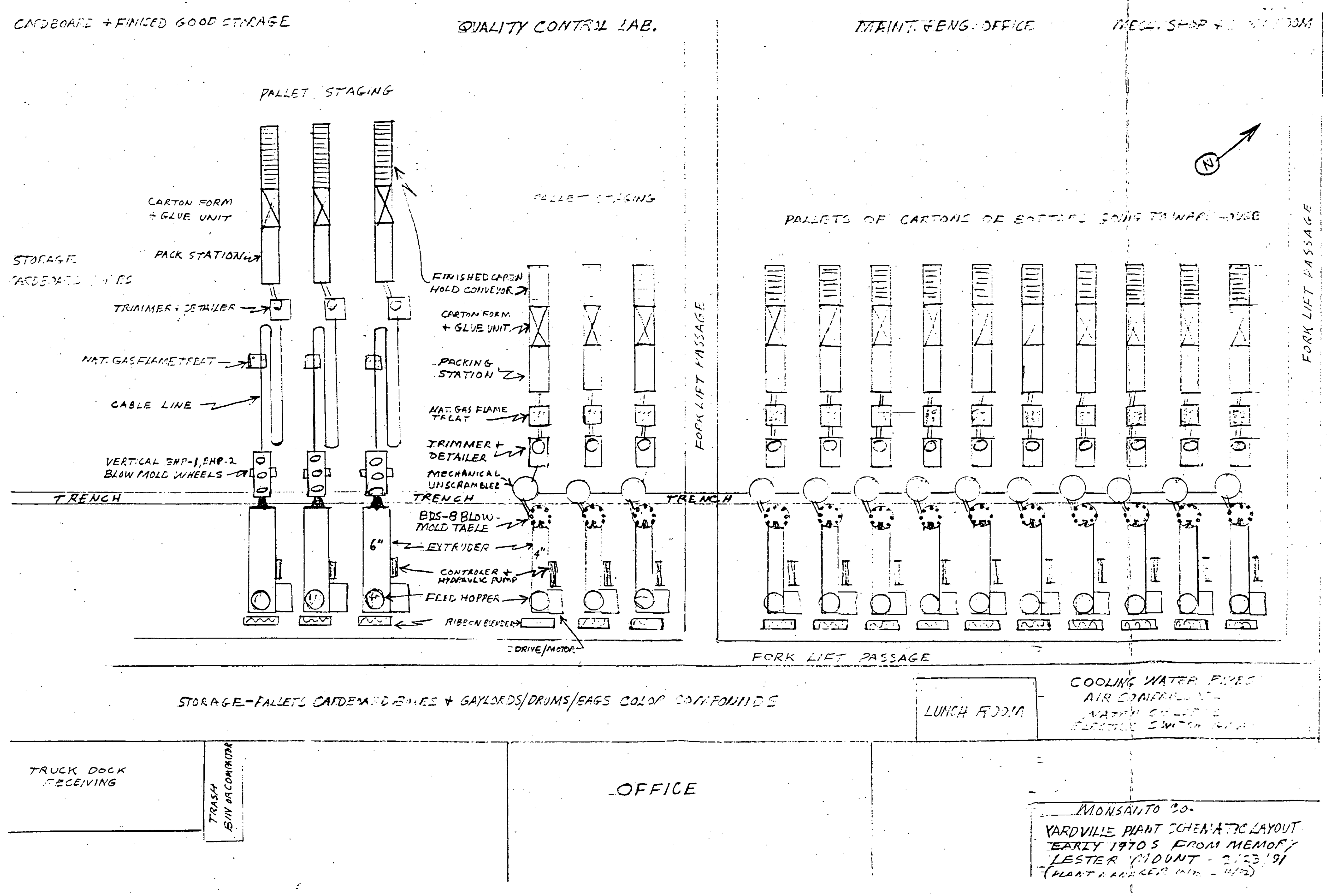

CARDBOARD + FINISED GOOD STORAGE
QUALITY CONTROL LAB.
MAINT. & ENG. OFFICE
PALLET STAGING
N
CARTON FORM
+ GLUE UNIT
STORAGE
CARDBOARD BOXES
PACK STATION
TRIMMER + DETAILER
NAT. GAS FLAME TREAT
CABLE LINE
VERTICAL BHP-1, BHP-2
BLOW MOLD WHEELS
TRENCH
FINISHED CARTON
HOLD CONVEYOR
CARTON FORM
+ GLUE UNIT
PACKING
STATION
NAT. GAS FLAME
TREAT
TRIMMER +
DETAILER
MECHANICAL
UNSCRAMBLER
BDS-8 BLOW-
MOLD TABLE
6"
4"
EXTRUDER
CONTROLER +
HYDRAULIC PUMP
FEED HOPPER
RIBBON BLENDER
DRIVE/MOTOR
PALLET STAGING
FORK LIFT PASSAGE
PALLETS OF CARTONS OF BOTTLES GOING TO WAREHOUSE
FORK LIFT PASSAGE
FORK LIFT PASSAGE
STORAGE-PALLETS CARDBOARD BOXES + GAYLORDS/DRUMS/BAGS COLOR COMPOUNDS
LUNCH ROOM
COOLING WATER PIPES
AIR COMPRESSOR
ELECTRIC SWITCH
TRUCK DOCK
RECEIVING
TRASH
BIN OR COMPACTOR
OFFICE
MONSANTO CO.
YARDVILLE PLANT SCHEMATIC LAYOUT
EARLY 1970S FROM MEMORY
LESTER MOUNT - 2/23/91
(PLANT MANAGER



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